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ABSTRACT

This series of activities on spatial relationships was designed to help users acquire the skills of spatial visualization and orientation and to improve their effectiveness in applying those skills. The series contains an introduction to spatial orientation with several self-directed activities to help improve that skill. It also contains seven sets of exercises that focus primarily on spatial visualization: memory of shapes, figure completion, rotation, spatial memory and rotation, hidden shapes, and cutout forms. Each set begins with fairly simple exercises and progresses to those that are more difficult. In addition, each set builds on the skills of the previous ones. The sets of exercises are appropriate for all age levels, with the exception of prekindergarten. The activities are self-contained and can be completed with or without the supervision of an instructor. Each set of activities contains an instruction sheet that gives the objective(s) of the set, examples of everyday applications, directions for use, and suggestions for self-directed practice. Answers are given on the back of each exercise page for those who want immediate feedback and also on a separate solutions page that concludes each set of activities. Careers contingent upon the ability to perceive spatial relationships are listed and readings and games are suggested. (PN)

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Spatial Encounters

Exercises in Spatial Awareness

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Spatial Encounters

Exercises in Spatial Awareness

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Women's Educational Equity Act Program
U.S. Department of Education

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Introduction

Women, as a consequence of socialization or genetics or both, have difficulty perceiving relationships in and among three-dimensional objects. For example, some women find it difficult to understand a cross-sectional drawing, to drive a car in reverse, or to determine how a mechanical object works by simply looking at it. Many women do not automatically learn, at home or at school, the total concept of space, which includes direction, distance, perspective, movement, and relationships of objects to each other in space. Much of the inability to grasp spatial relationships is a consequence of limited social opportunities to develop such skills--for example, playing games requiring coordination, handling three-dimensional objects such as building materials or toys with movable parts, or enrolling in mechanical drawing courses. Women have consistently shown a sex-differentiated lack of what is called spatial visualization and spatial orientation. Most men acquire these skills and then build on them both in the learning process and on the job.

Spatial visualization and spatial orientation are terms from psychology that describe the ability to judge spatial relationships. Spatial visualization involves the ability to manipulate and rotate mentally two- and three-dimensional objects. Spatial orientation involves the ability to perceive the elements in a pattern, to compare patterns, to grasp changing orientation in space, and to determine the position of one's body in space. The spatial skills of visualization and orientation are highly correlated with success in a number of technical and professional occupations that have traditionally been considered male domains.

Spatial ability is a part of the psychology of perception (the process of extracting meaningful information from sensory stimulation) and is intricately involved with learning and thinking. At the present time, instruction based on the skills of spatial visualization or orientation is not learned as well by females as by most males. When information is presented in spatial terms, or when learning requires spatial skills, women often fear, do not understand, or have difficulty with the material.

Numerous research studies in psychology have concluded that males are superior to females in spatial perception, but that this difference can be diminished, if not eliminated, through adequate training. In order to allow freedom of career choice, people of both sexes should have the opportunity to learn the perceptual skills necessary to enter the mathematics, engineering, science, and technical professions.

DESCRIPTION OF ACTIVITIES

This series of activities on spatial relationships was designed to help the user acquire the skills of spatial visualization and orientation and to improve her or his effectiveness in applying those skills. The series contains an introduction to spatial orientation with several self-directed activities to help improve that skill. It also contains seven sets of exercises that focus primarily on spatial visualization. Each set begins with fairly simple exercises and progresses to those that are more difficult. In addition, each set builds on the skills of the previous ones. The user should begin with the basic exercises in each set, even if they seem fairly easy. It's a good idea not to skip any. This is one time where practice does help.

The sets of exercises are appropriate for all age levels, with the exception of prekindergarten. Young children can do many of the activities with the assistance of an adult. The younger a person is when she or he begins to develop spatial abilities, the more likely it is that those abilities will remain an integral part of her or his perceptual ability.

The activities are self-contained and can be completed with or without the supervision of an instructor. Teachers should find them easy to adapt for classroom use. The activities should not be viewed as tests; they are designed to help users improve their spatial skills.

Each set of activities contains an instruction sheet that gives the objective(s) of the set, examples of everyday applications, directions for use, as well as suggestions for self-directed practice. Trying some of these structured activities is important; their incorporation into everyday activities will greatly increase spatial skills and one's confidence in them.

Answers are given on the back of each exercise page for those who want immediate feedback and also on a separate solutions page that concludes each set of activities. There is a blank answer sheet that can be removed so that answers can be marked on it, allowing the exercises to be completed several times.

SPATIAL ORIENTATION

A specific type of spatial ability is called spatial orientation. This involves the ability to perceive patterns and to compare them with one another: to understand how elements are arranged within a visual pattern; not to be confused when objects change their positions in space; and to determine spatial location with respect to one's body.

Spatial orientation is necessary for tasks that require a sense of direction. Map reading, finding one's way in an unfamiliar locale, and using or explaining perspective are good examples of such tasks.

To improve spatial orientation skills, you can do the following exercises.

Engage in any general physical activity, such as playing Frisbee, volleyball, tennis, or pool. Other activities which may be useful include dancing and tumbling.

Try parallel parking and driving in reverse.

Play electronic games in which you have to understand patterns and how they are arranged or you have to determine the spatial relationships with respect to your own body.

Read and interpret topographical maps.

Practice with a bow and arrow. Mentally connect your arrow to the target.

As you drive in the country or ride a bicycle, envision the entire landscape. Don't just follow the painted lines or signs that go around a curve. Visualize where the curve has to go and what it will look like ahead.

Look farther ahead when walking and driving.

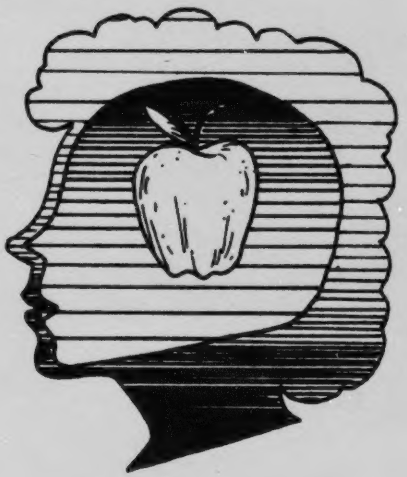
Move to music.

Use simple tumbling to learn where your body goes in space.

Read maps. Have someone listen as you outline a route on a standard city map. Then mentally follow that route, telling the direction of various turns (right or left; north or south) with respect to your original starting point.

Draw maps.

Play games using maps. Tell verbally how to get from one point to another point by the shortest route.



Memory of Shapes

SPATIAL ENCOUNTERS

MEMORY OF SHAPES

OBJECTIVE

To form a visual image of an object and then to remember its shape.

DIRECTIONS

First, look through the activities. Notice that each page contains two drawings. Look at the drawing on the right-hand side of the page until you think you can remember it -- see it in your mind. It is important to remember what the object looks like, rather than just remembering its name. Now, turn the page and select the object on the left-hand side of the page that you remember from the page before. Mark your answer on the sheet provided. Then you can check the answer on the back of the page to see that it is correct. Continue in this way until you have done all the exercises.

If you answer all the exercises correctly, go to the set of exercises on *Figure Completion*. But, if you miss some, and most people will, try the other types of activities suggested under "What Else Can You Do?" on the next page. Then work through the exercises again.

Another way of approaching the exercises is to work all the way through them before checking any of the answers. A separate solutions page is given at the end of the exercises for this purpose. Completing all the activities before checking an answer is especially effective if you want to work through the set several times.

APPLICATION

Visual memory is required often in everyday activities. Try to remember just where a store is on a street, or where you left something in a room. You may try to remember what a pair of slacks or a suit looked like after leaving a store or what your favorite camping site looks like. You might also try to recall the pattern for knitting a sweater or the blueprint for building a cabinet.

Visual memory is required for careers such as engineering, geography, dentistry, forestry, city planning, industrial design, mathematics, landscape architecture, and quality control.

MEMORY OF SHAPES

WHAT ELSE CAN YOU DO?

Describe to someone the neighborhood in which you live. Try to "see" the details as you talk. Don't use street names.

Look at a picture. Look away and see how much of it you can remember. Try to remember exact placement of things.

Read a story and then close your eyes. Try to visualize what the characters look like, what the streets and houses and clothes look like.

Walk around your house "mentally." See the texture, the angles. Where are the plants located?

Try to draw familiar objects from memory -- your dog, car, bicycle, shoes, living room, etc.

Touch a three-dimensional form, either real or abstract, with your eyes closed and try to visualize it.

Picture an object in your mind. Scan it, paying attention to all the details as you do so. Then zoom in on one small part -- picture it in detail in your mind.

Practice twenty questions. What twenty things can I visualize? Close your eyes and see them.

Practice visual "limbering up" exercises. Let the images flow freely. Allow daily time for relaxing, daydreaming.

LIST YOUR OWN IDEAS FOR IMPROVING YOUR MEMORY OF SHAPES

ANSWER SHEET
MEMORY OF SHAPES

1 A B C D
2 A B C D
3 A B C D
4 A B C D
5 A B C D
6 A B C D
7 A B C D
8 A B C D
9 A B C D
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22 A B C D
23 A B C D
24 A B C D
25 A B C D
26 A B C D
27 A B C D
28 A B C D
29 A B C D
30 A B C D
31 A B C D

LOOK AT THE OBJECT IN THE BOX ON THE RIGHT. TURN THE PAGE. FIND THE SAME OBJECT IN THE BOX ON THE LEFT. CIRCLE THE CORRECT ANSWER. THEN, LOOK AT THE OBJECT IN THE BOX ON THE RIGHT AGAIN. TURN THE PAGE AND FIND IT IN THE BOX ON THE LEFT. CONTINUE IN THIS WAY FOR EACH EXERCISE.

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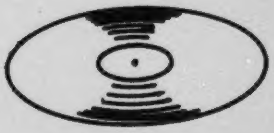

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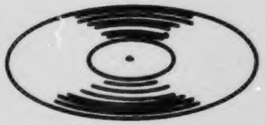

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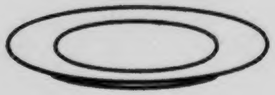

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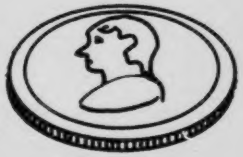

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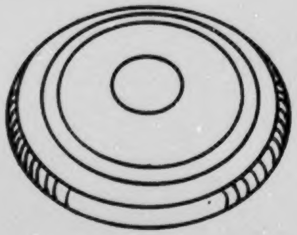

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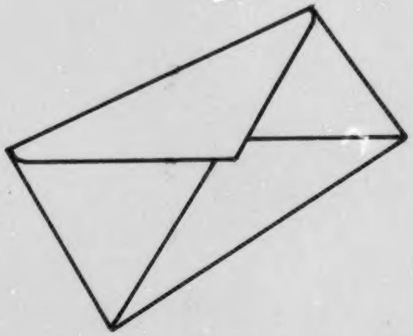

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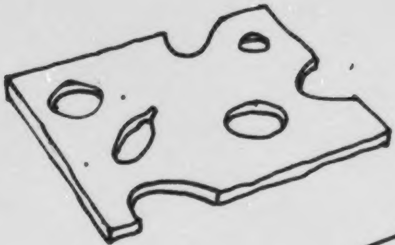

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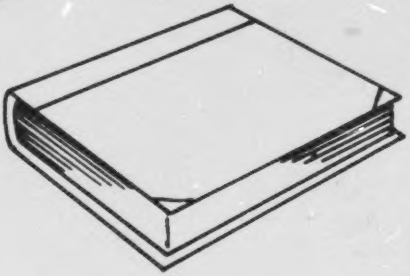

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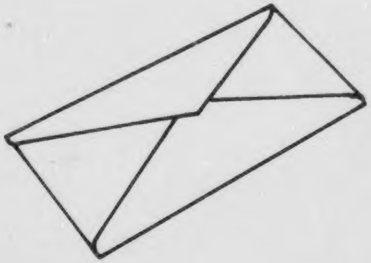

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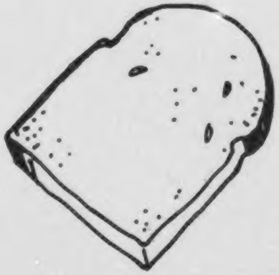

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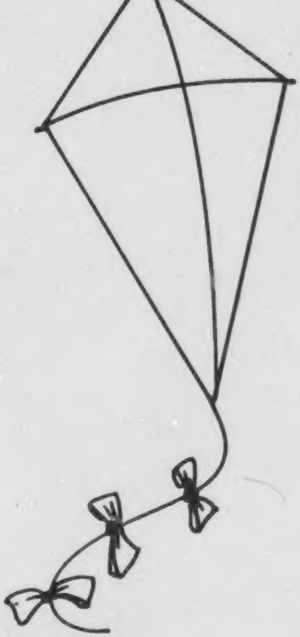

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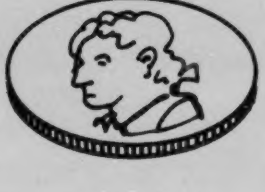

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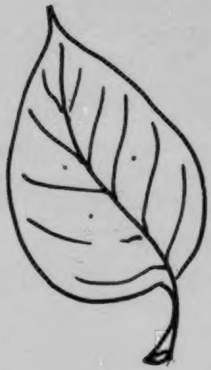

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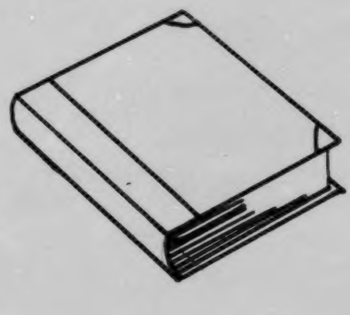

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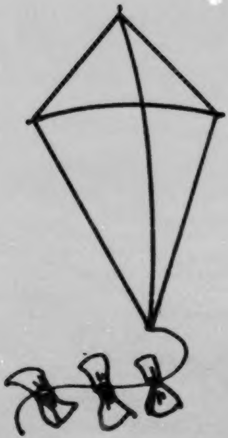

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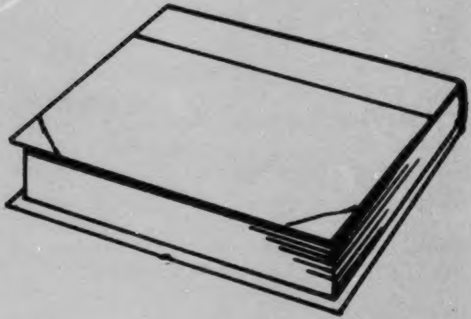

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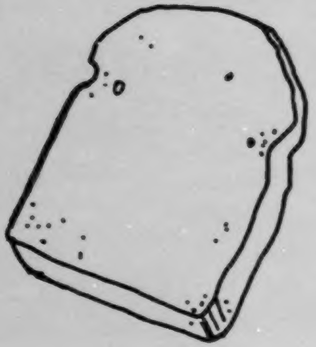

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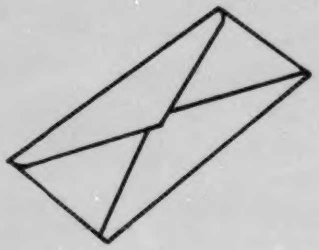

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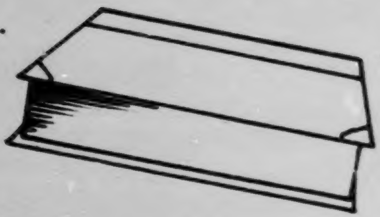

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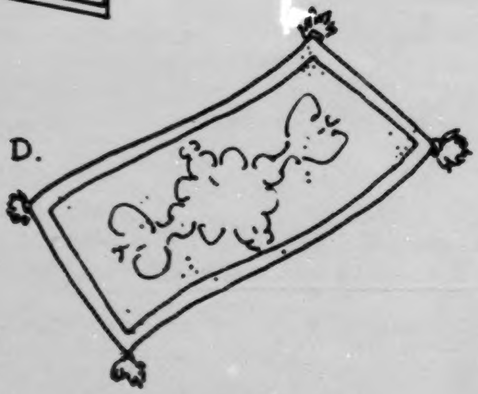

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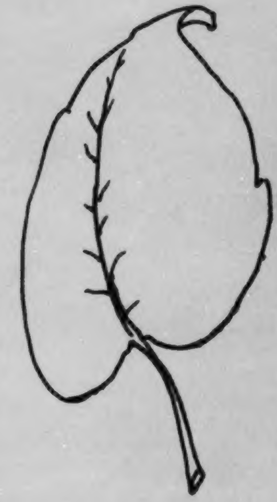

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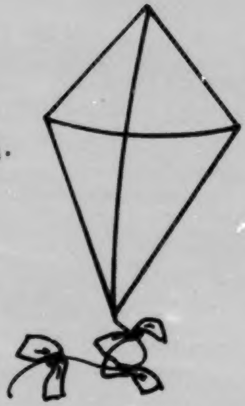

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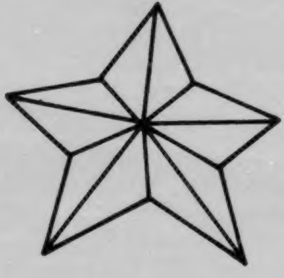

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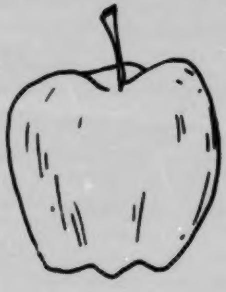

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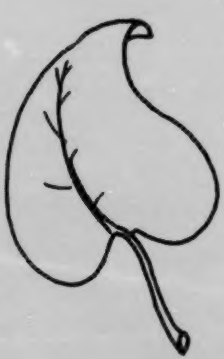

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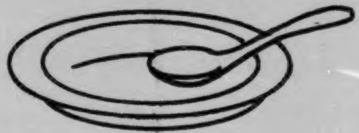

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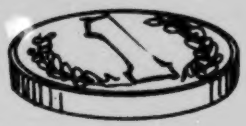

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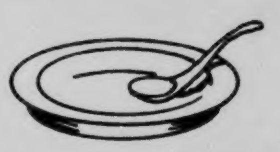

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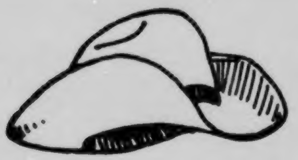

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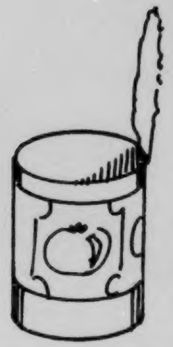

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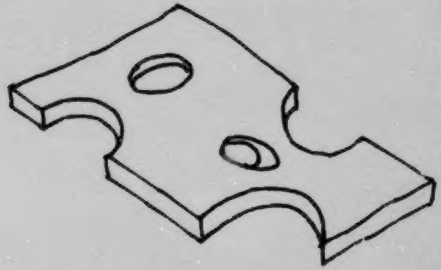

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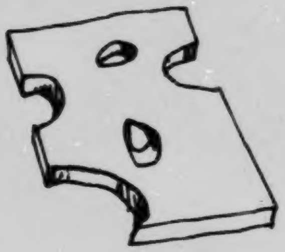

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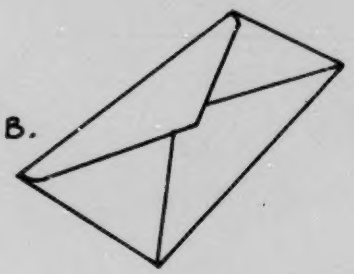

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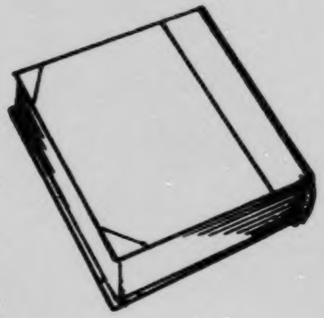

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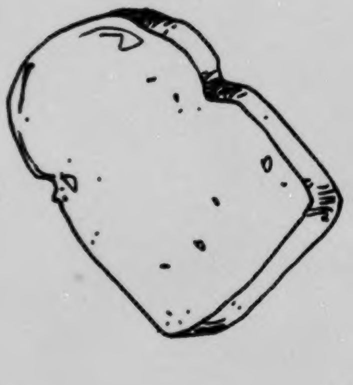

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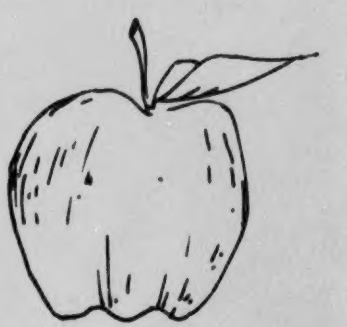

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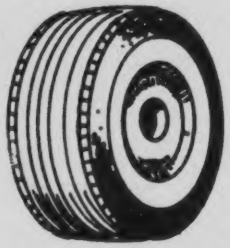

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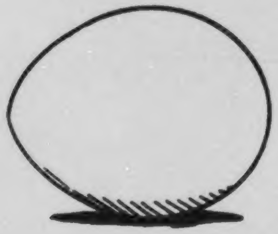

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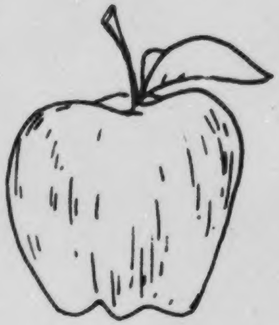

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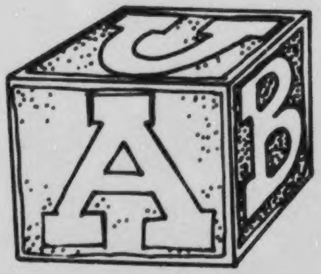

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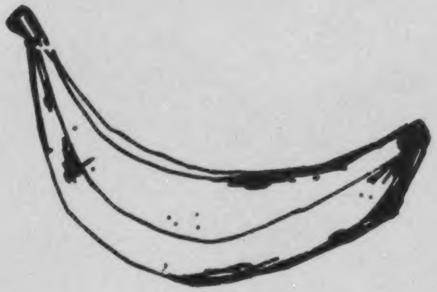

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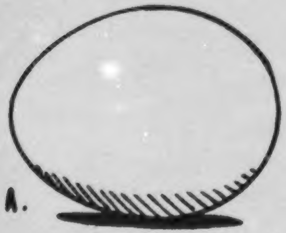
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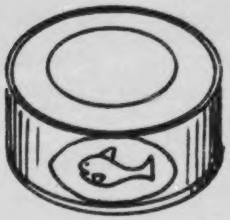
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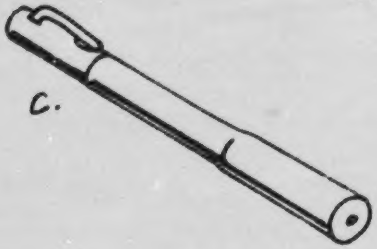
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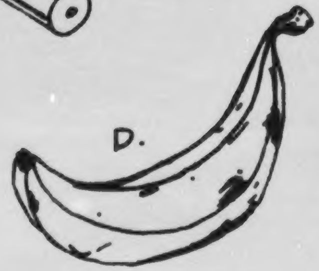
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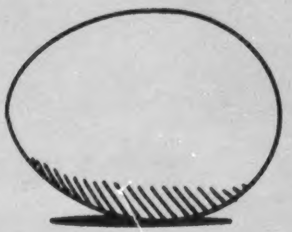

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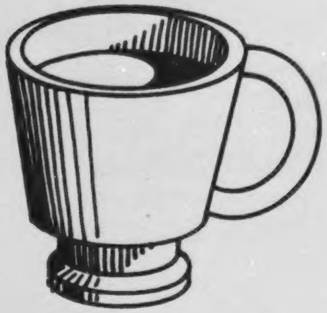

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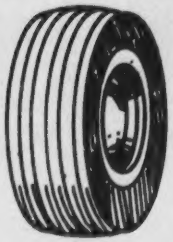

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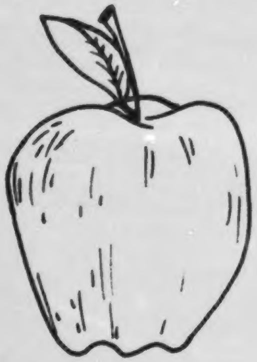

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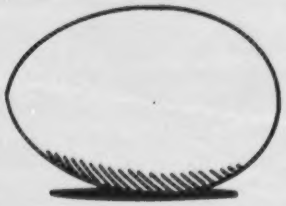

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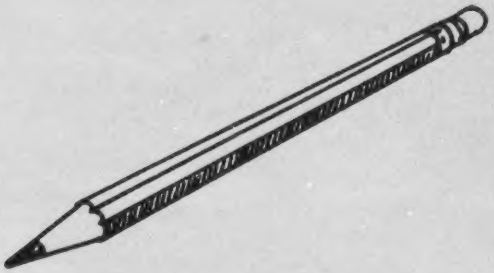

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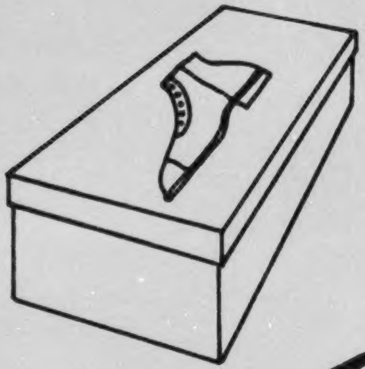

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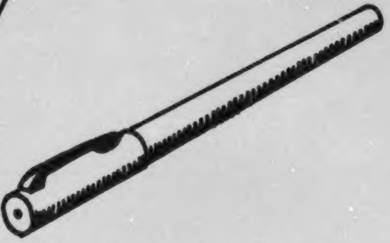

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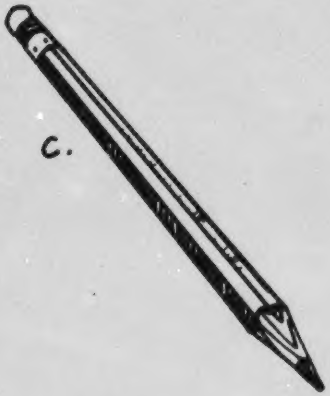

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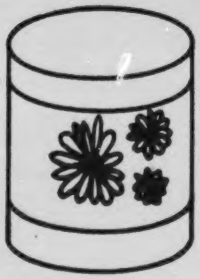

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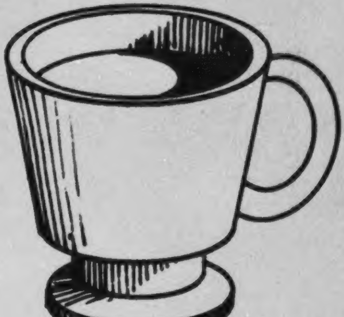

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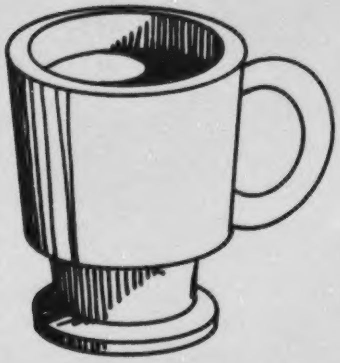

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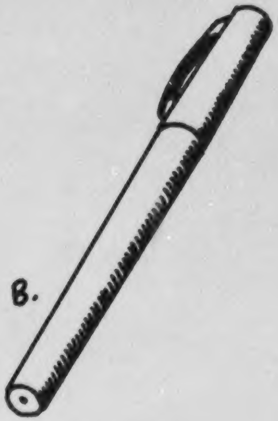

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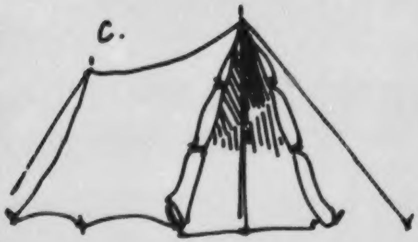

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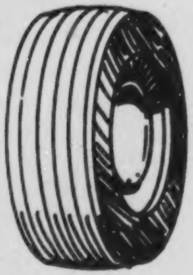

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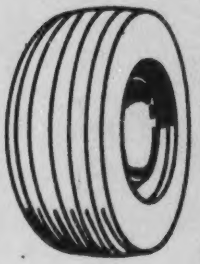

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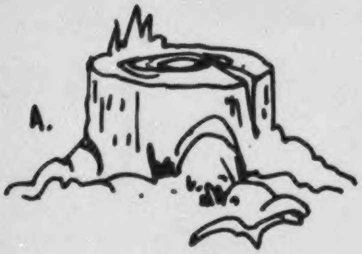

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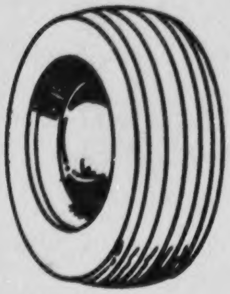

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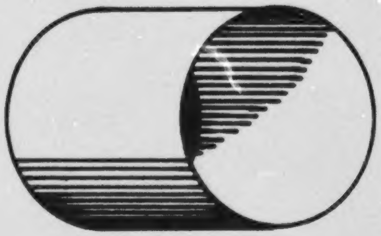

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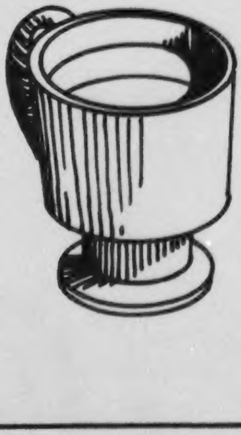

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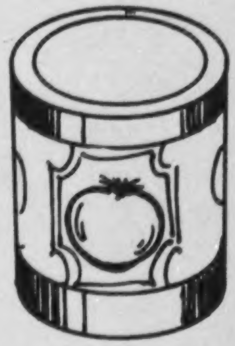

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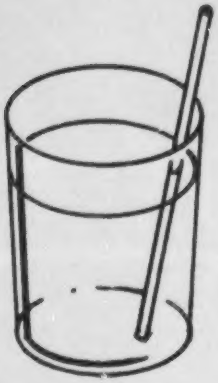

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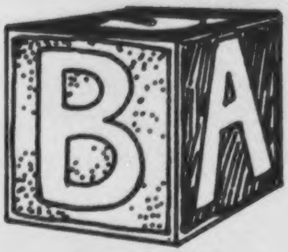

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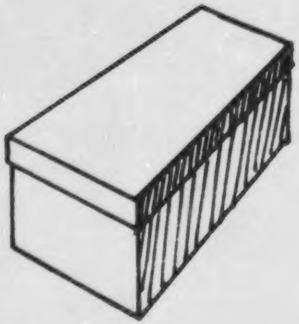

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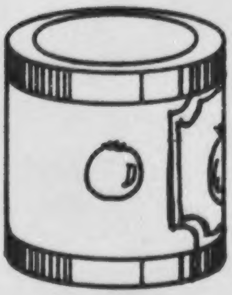

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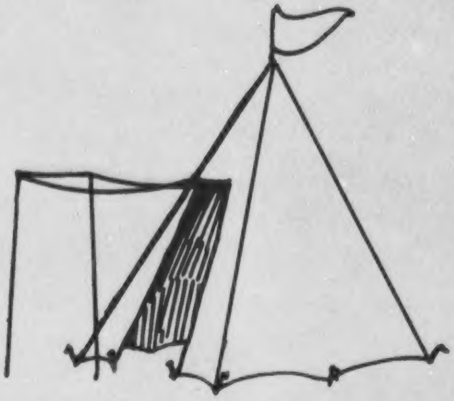

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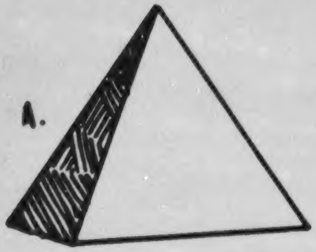

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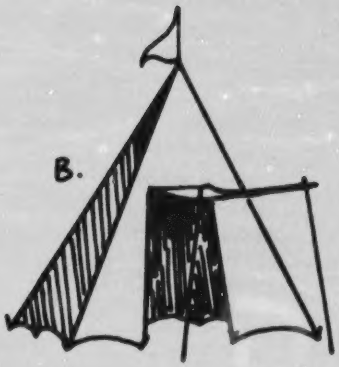

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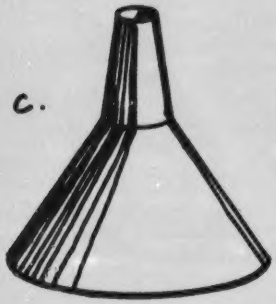

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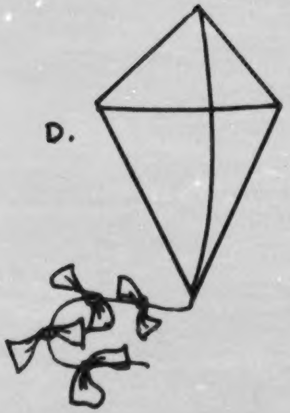

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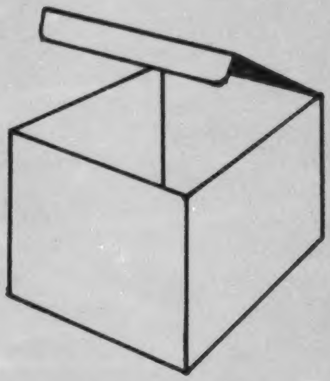

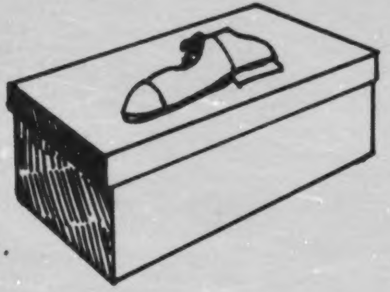

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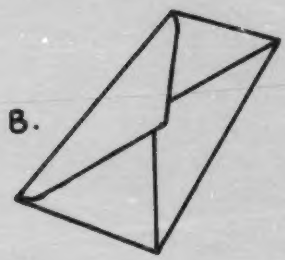

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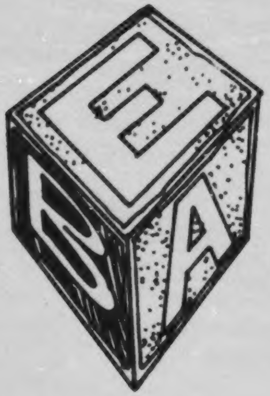

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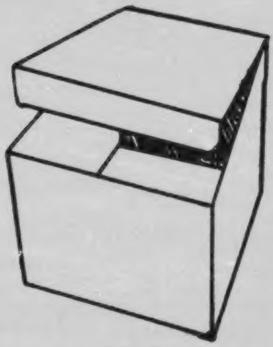

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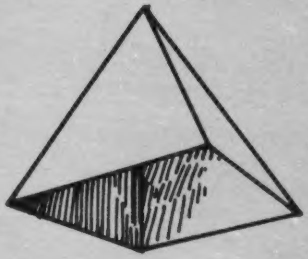

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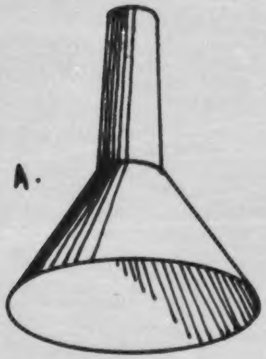

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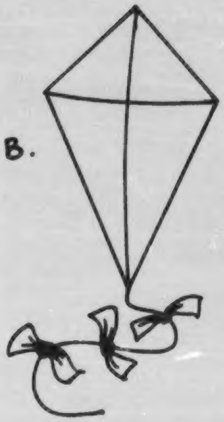

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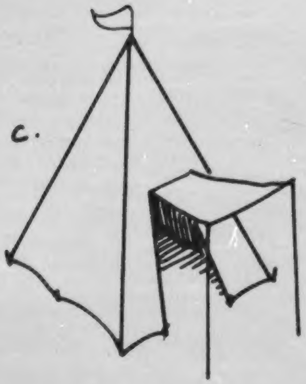

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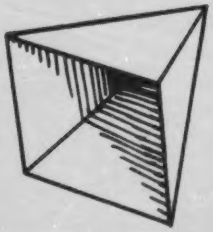

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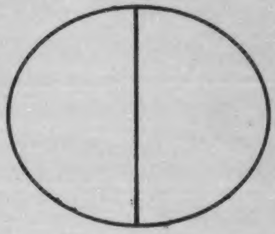

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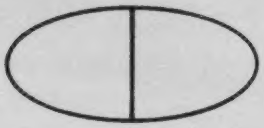

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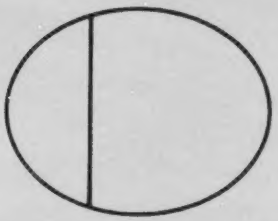

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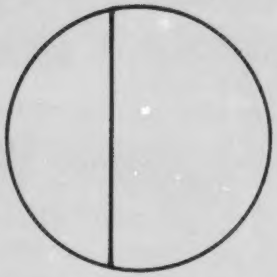

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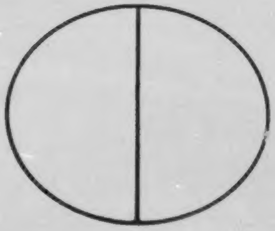

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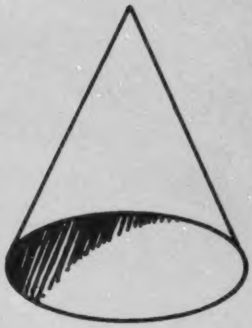

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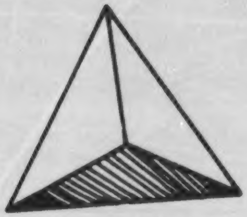

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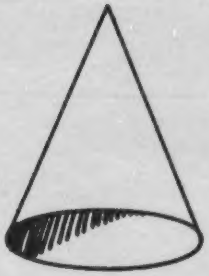

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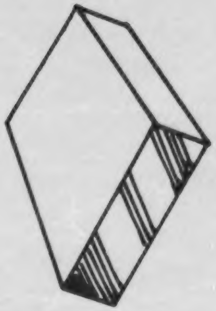

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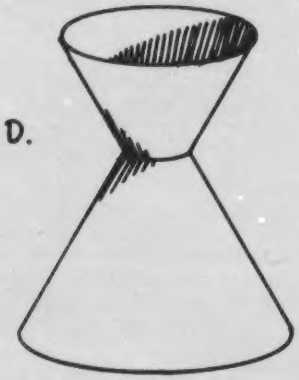

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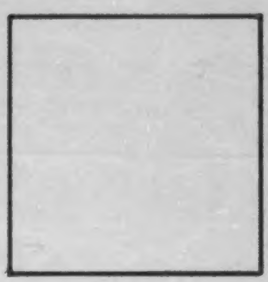

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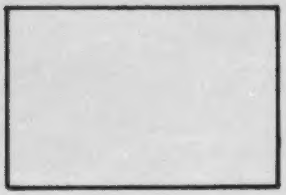

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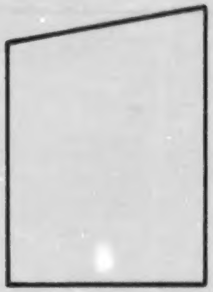

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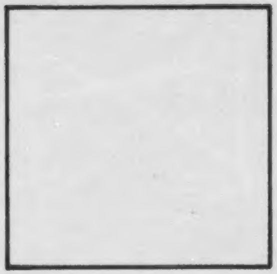

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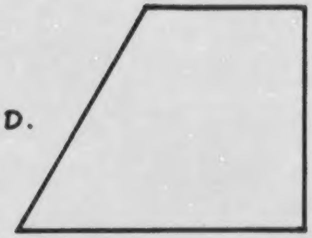

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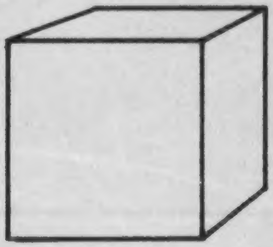

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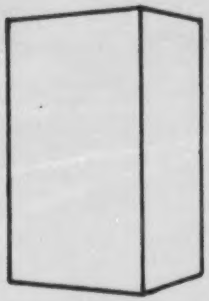

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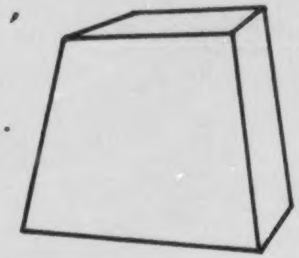

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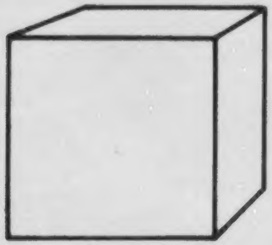

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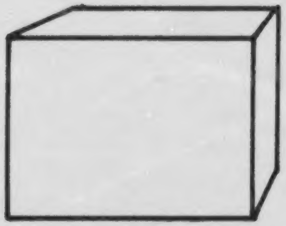

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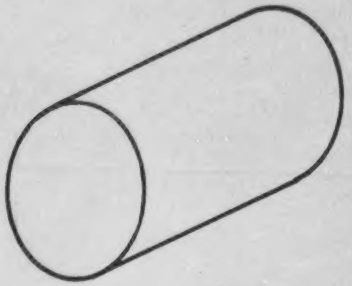

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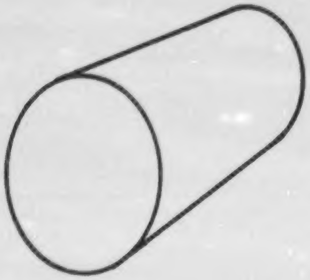

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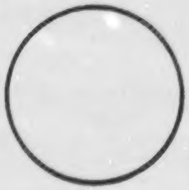

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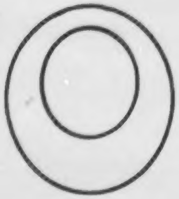

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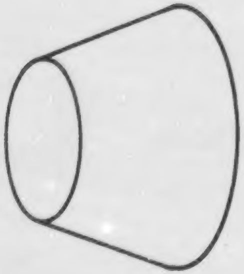

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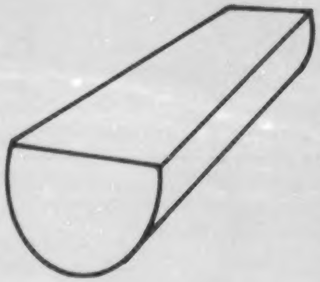

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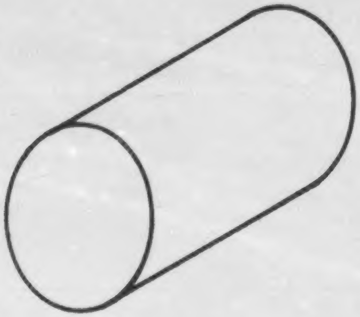

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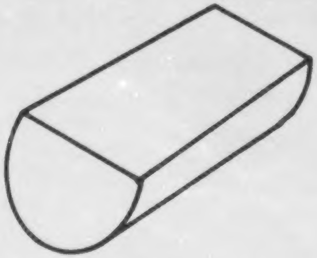

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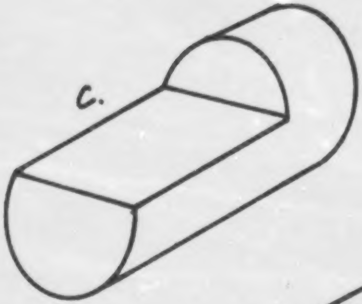

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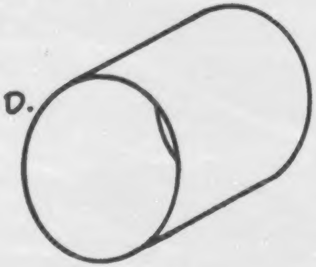

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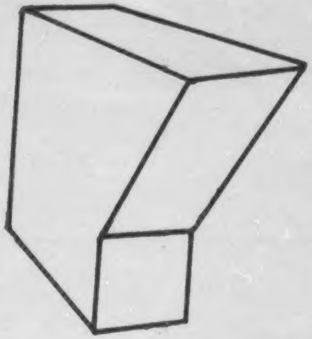

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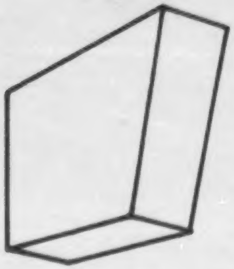

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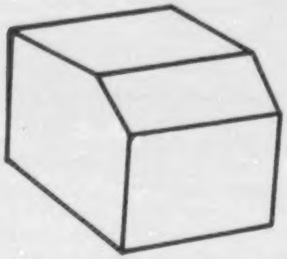

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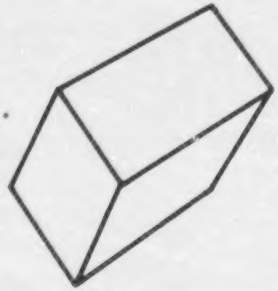

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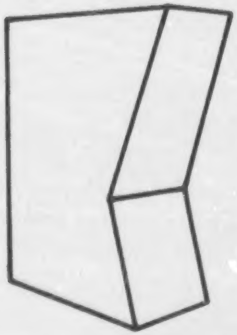

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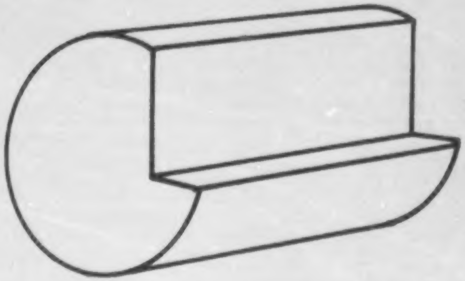

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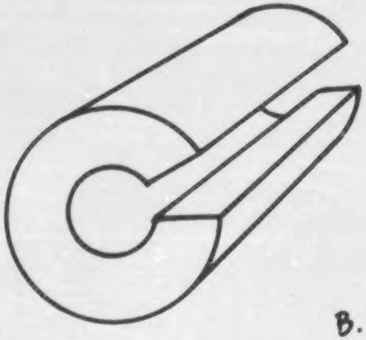

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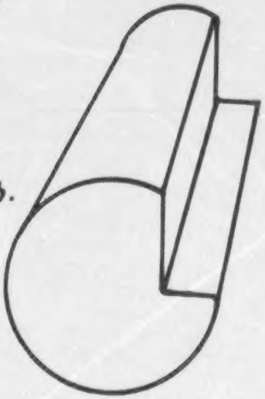

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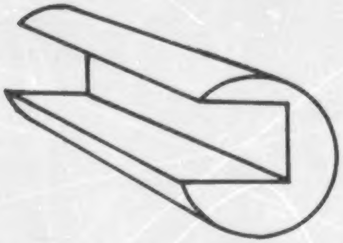

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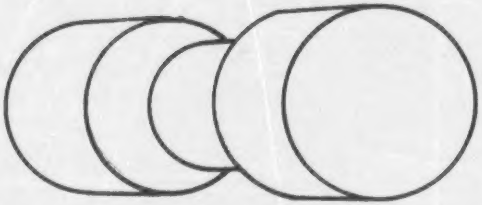

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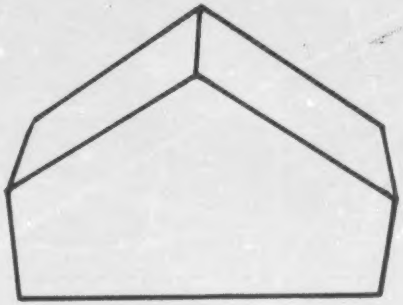

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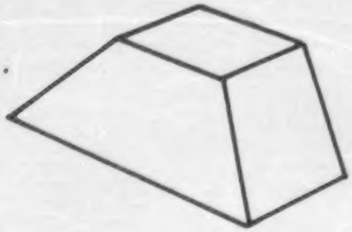

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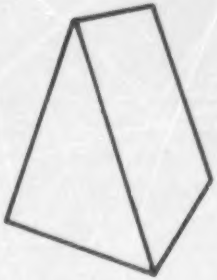

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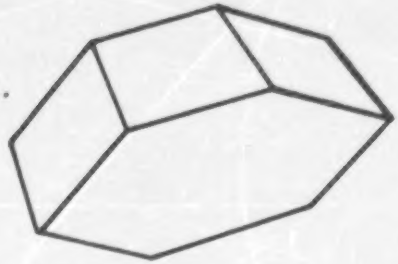

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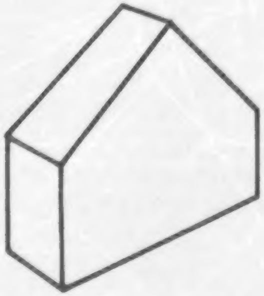

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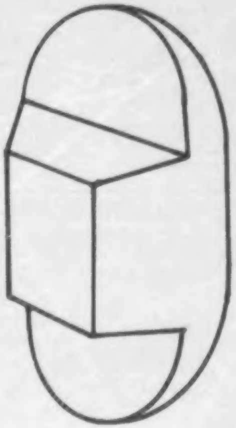

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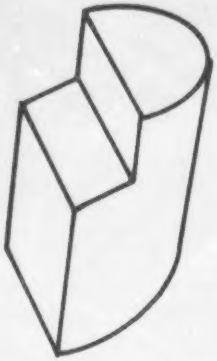

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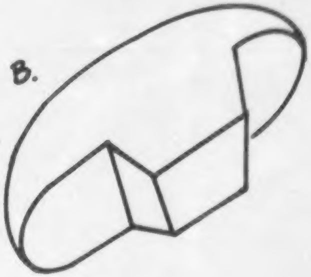

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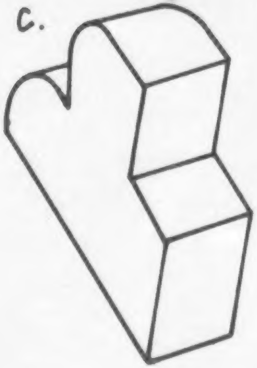

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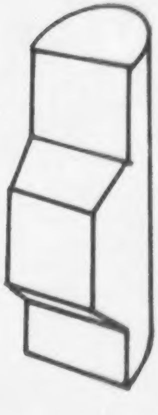

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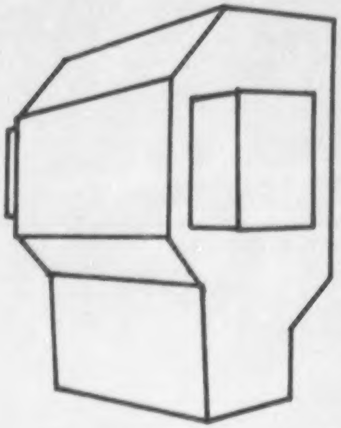

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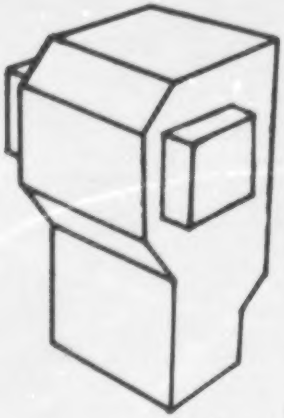

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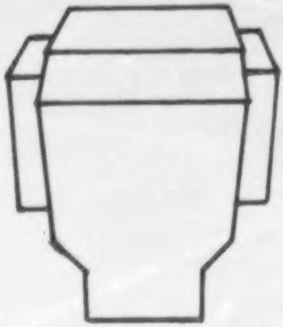

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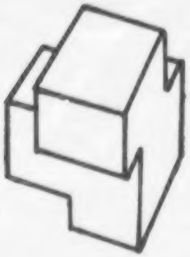

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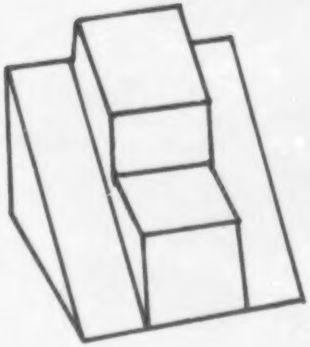

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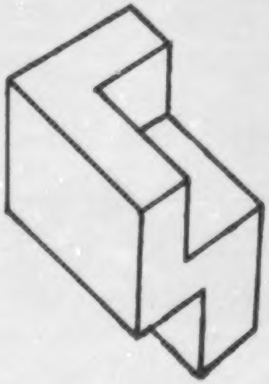

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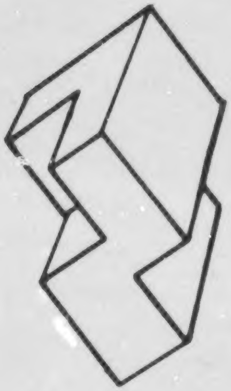

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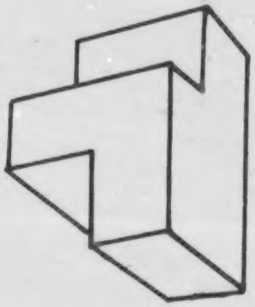

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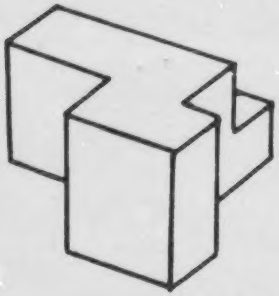

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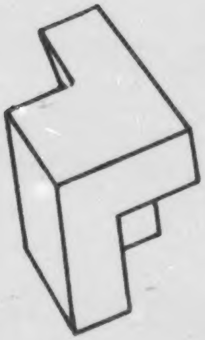

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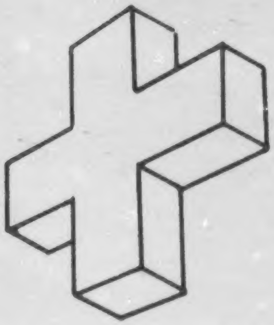

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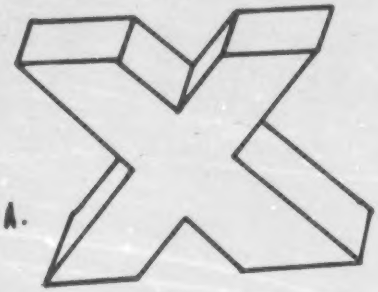

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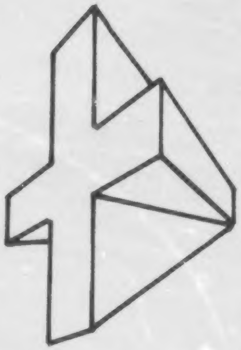

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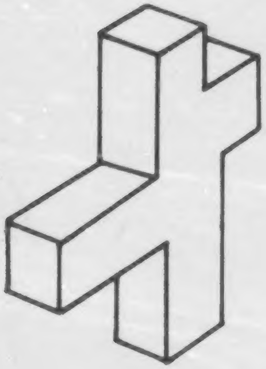

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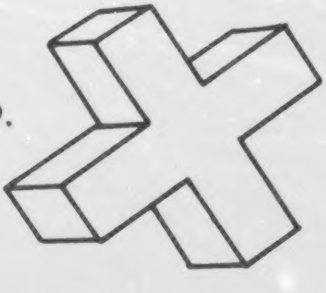

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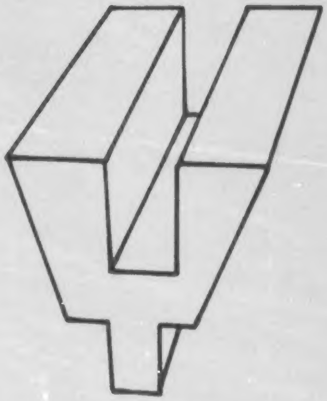

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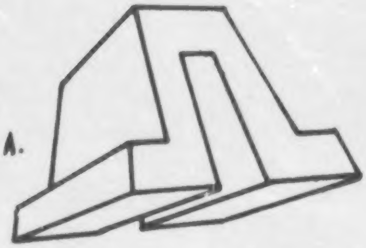

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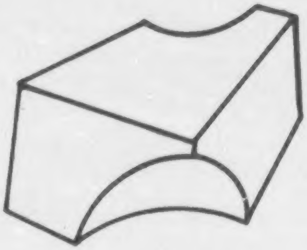

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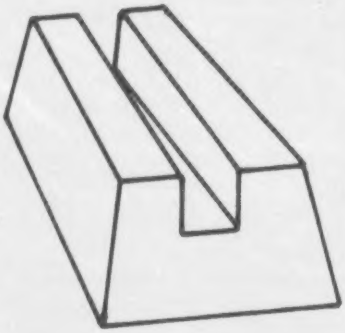

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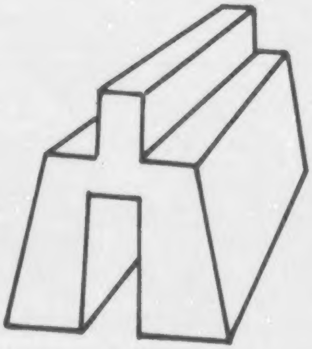

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SOLUTIONS

MEMORY OF SHAPES

1 [✓ A] B C D
2 A B [✓ C] D
3 A B C [✓ D]
4 A B [✓ C] D
5 A B C [✓ D]
6 A [✓ B] C D
7 [✓ A] B C D
8 A B [✓ C] D
9 A B C [✓ D]
10 A B C [✓ D]

11 A B [✓ C] D
12 [✓ A] B C D
13 A [✓ B] C D
14 A B C [✓ D]
15 A [✓ B] C D
16 A B C [✓ D]
17 A B C [✓ D]
18 A B C [✓ D]
19 A [✓ B] C D
20 A B [✓ C] D

21 A B [✓ C] D
22 [✓ A] B C D
23 A [✓ B] C D
24 A B C [✓ D]
25 A [✓ B] C D
26 A B C [✓ D]
27 A [✓ B] C D
28 [✓ A] B C D
29 [✓ A] B C D
30 A B C [✓ D]
31 A B C [✓ D]

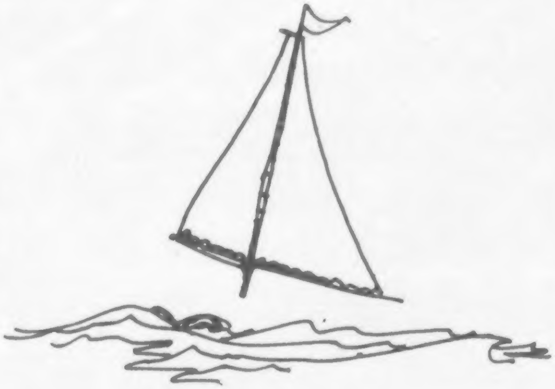

Figure Completion

FIGURE COMPLETION

OBJECTIVES

To draw conclusions from limited perceptual information.
To create an image of the whole from a part.

DIRECTIONS

Each of these exercises contains an incomplete drawing of an object. The idea is to look at the incomplete drawing and visualize what it would look like finished. To the right of each incomplete drawing are three finished pictures. Select the one that is the completed drawing of the figure in the box on the left. Mark your answer on the sheet provided. Check your answer on the back of the page if you wish.

If you answer all the exercises correctly, go to the set of activities on *Rotation 1*. If some of your answers are not correct, you might want to try copying the pages and then cutting out the incomplete picture. Although the pictures do not match precisely, when you superimpose the incomplete drawing on the pictures on the right, you will be able to see which is the match. As you do this, try to visualize what you are doing when you match the drawings. See it in your mind. Then mentally lift the incomplete drawing off the page and fit it to a picture on the right. Now try working through the exercises again.

APPLICATION

The completion of a figure from limited information is often required in everyday life. People who sew imagine what the entire garment will look like when only part of it is done. A completed landscape is visualized from only small plants. An automobile driver needs to distinguish elements on the road while traveling through fog, at night, or when the sun glare obscures images of pedestrians or vehicles.

Figure completion is particularly important to some careers. An archaeologist creates a design from pieces of pottery. A civil engineer creates a bridge and an artist "sees" a completed figure from only a few sketched lines. Other careers that require the skill of figure completion are paleontology, geology, radiology, and chemistry.

FIGURE COMPLETION

WHAT ELSE CAN YOU DO?

Work jigsaw puzzles.

Do line teasers.

Work mazes.

Take a piece of construction paper and cut a shape out of it. Place the sheet of construction paper over a part of a photograph so that only a portion of the picture is showing through. Have someone try to guess what the picture is.

Take a look out of the window at a distant cylindrical object. The image probably will be obscure. Is it a telephone pole, a high voltage wire pole, a lamp post, or perhaps a flag pole?

Identify a cut of meat from a whole animal.

Try finger painting and visualize the finished work from the time you begin.

Cloud gaze -- visualize images in them.

Work with Tinkertoys. See the finished object from only a few connected pieces.

LIST YOUR OWN IDEAS FOR IMPROVING YOUR FIGURE COMPLETION ABILITY

ANSWER SHEET
FIGURE COMPLETION

1 A B C
2 A B C
3 A B C
4 A B C
5 A B C
6 A B C
7 A B C
8 A B C
9 A B C
10 A B C
11 A B C
12 A B C
13 A B C
14 A B C
15 A B C
16 A B C
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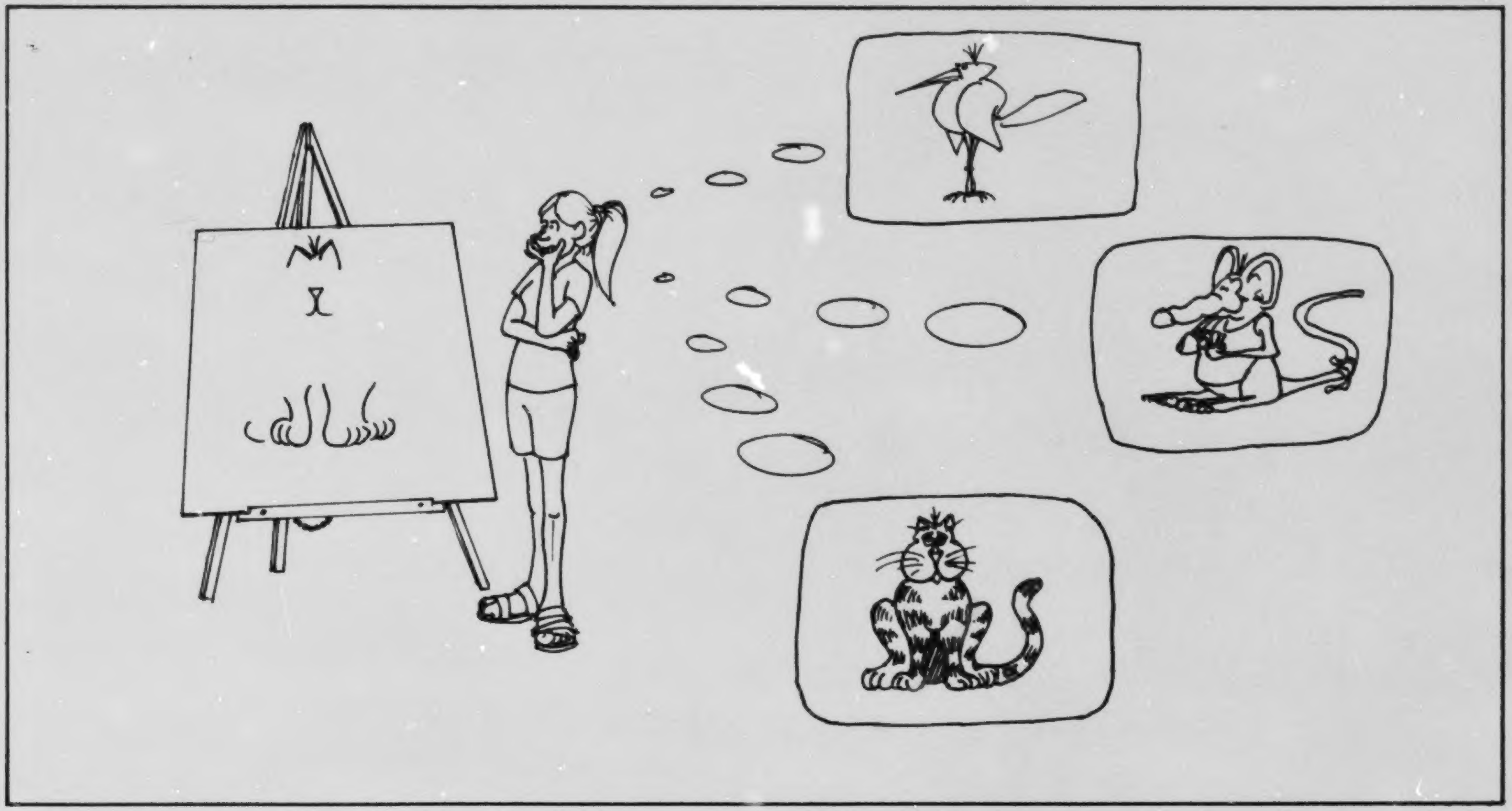
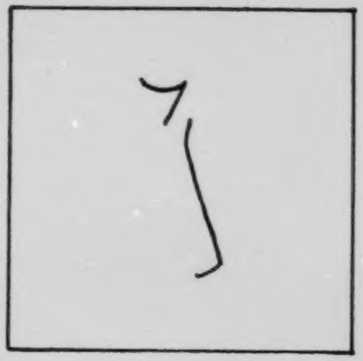


EXAMPLE

LOOK AT THE DRAWING ON THE LEFT. THE DRAWING IS NOT FINISHED. NOW LOOK AT THE FIGURES IN THE BOXES ON THE RIGHT. ONE OF THEM IS THE COMPLETED DRAWING OF THE FIGURE IN THE BOX ON THE LEFT. WHICH ONE IS IT? PLEASE CIRCLE THE CORRECT ANSWER. THEN, TURN THE PAGE AND CONTINUE.



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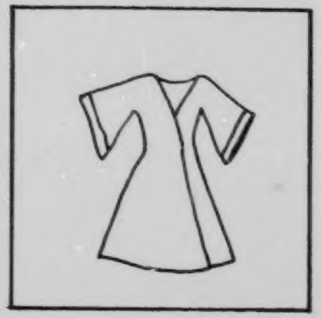

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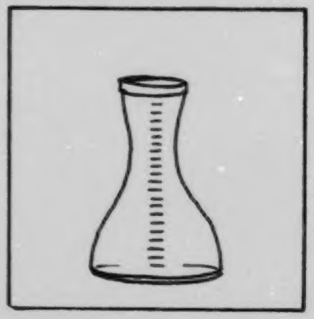

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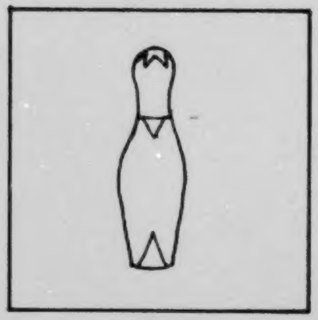

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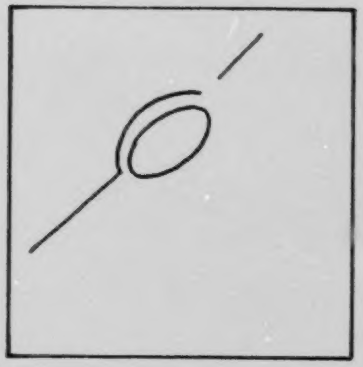

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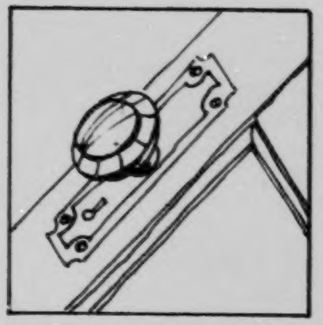

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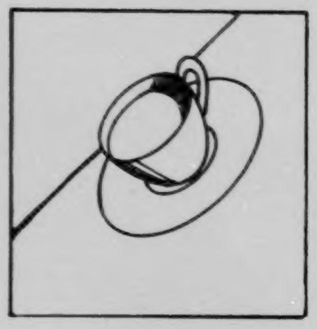

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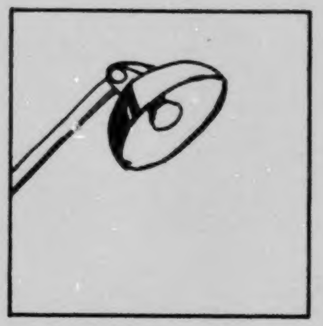

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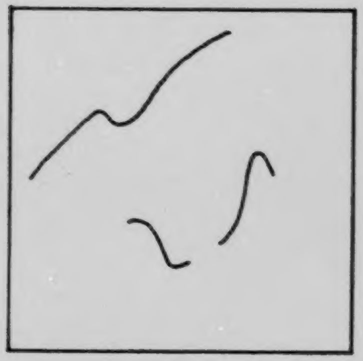

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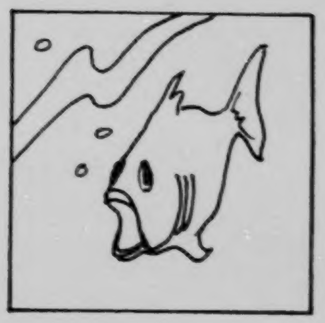

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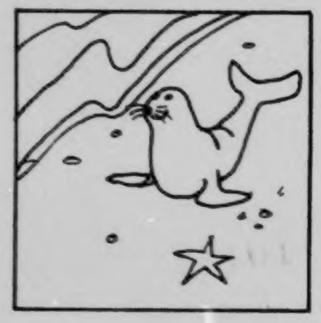

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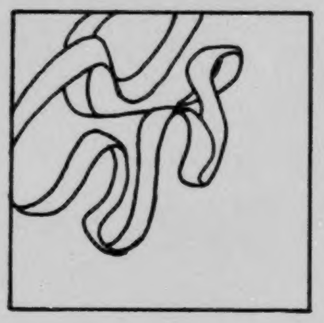
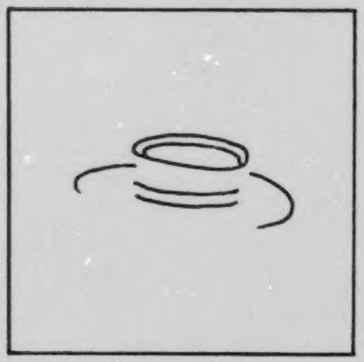


C.

1. A

2. B

3. A



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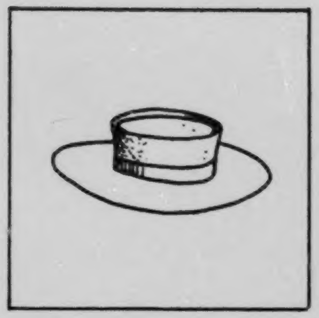

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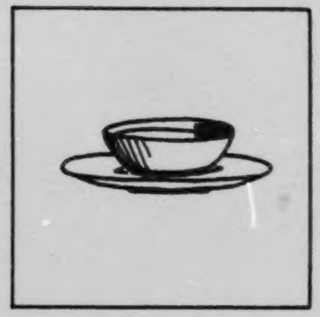

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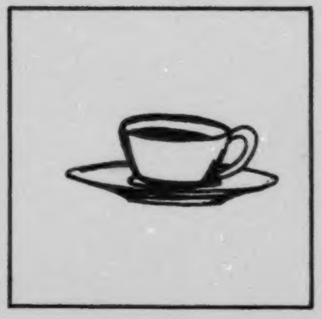

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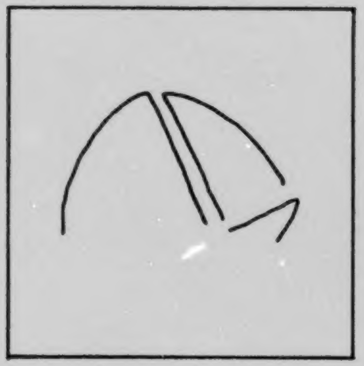

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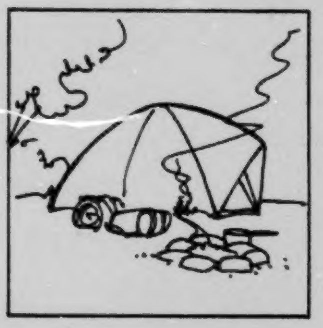

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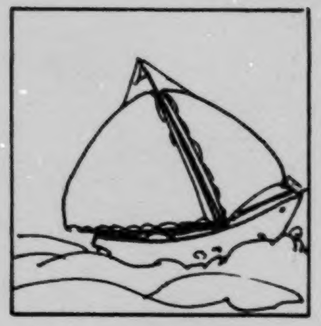

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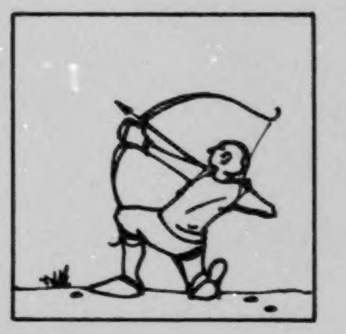

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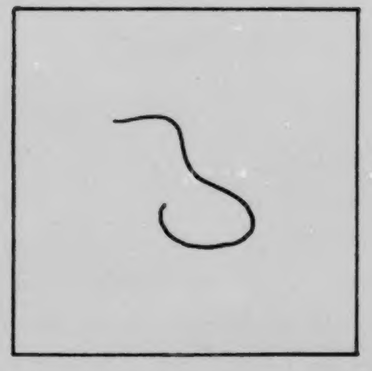

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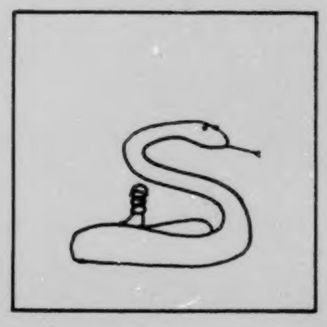

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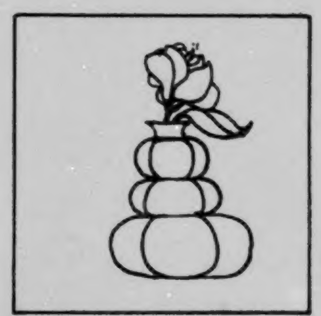

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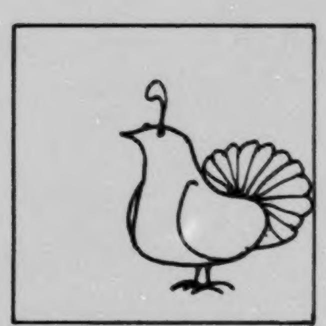


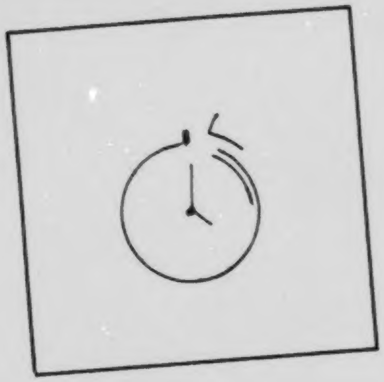
C.

4. A

5. B

6. C

104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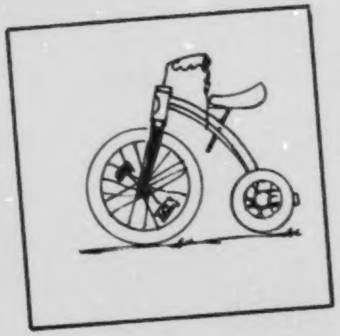
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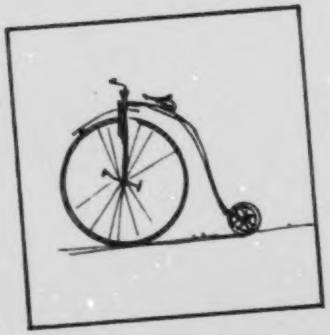
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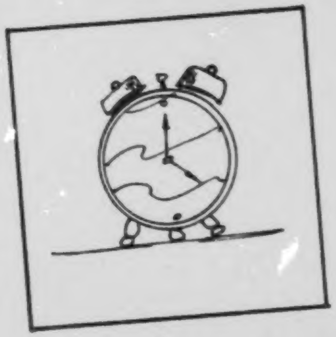
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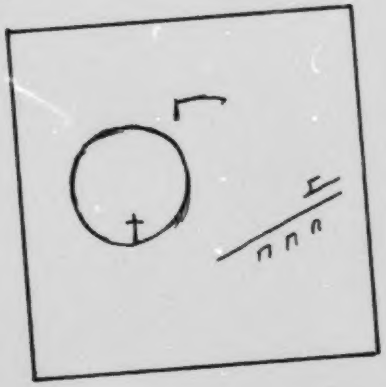
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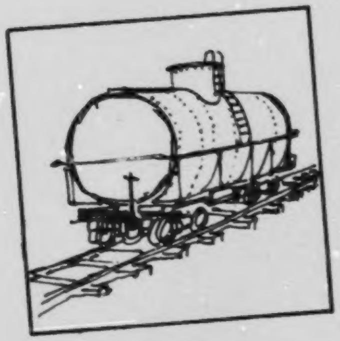
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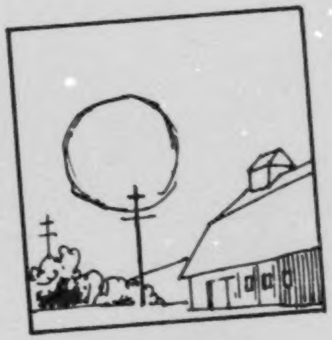
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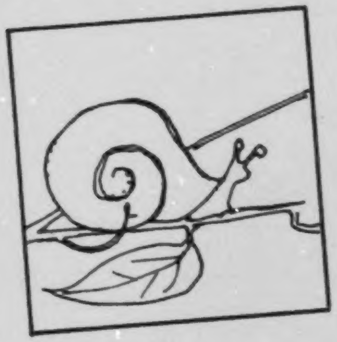
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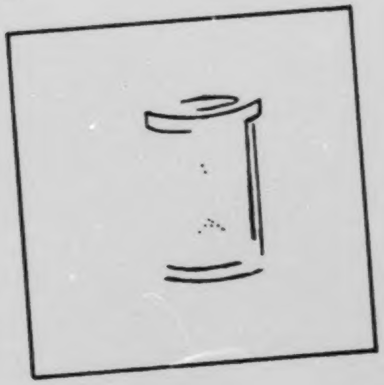
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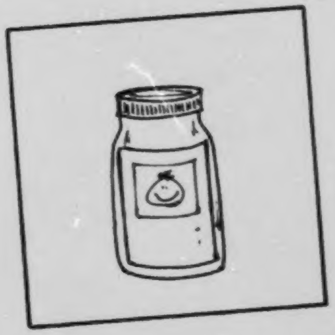
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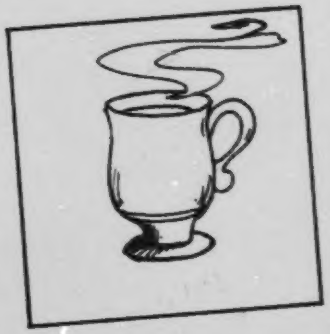
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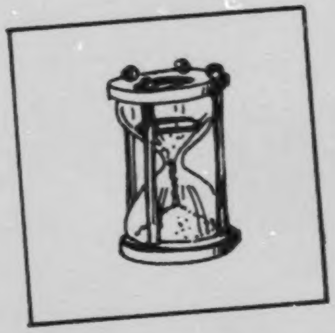
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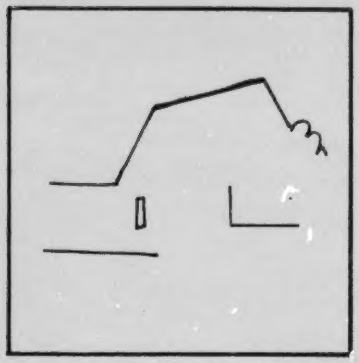
7. C

8. A

9. C

107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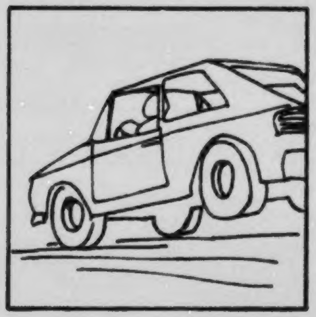
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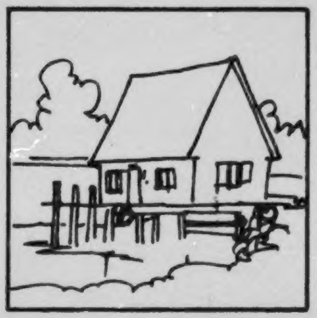
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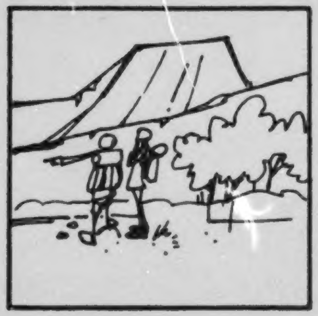
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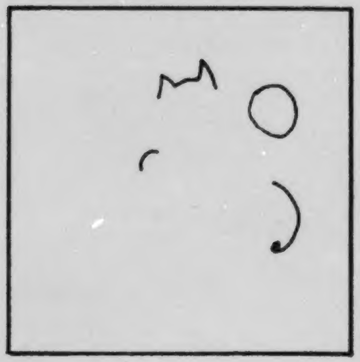
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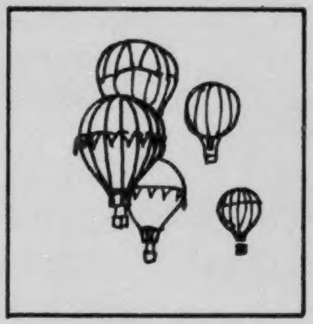
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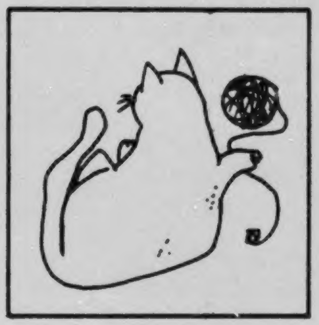
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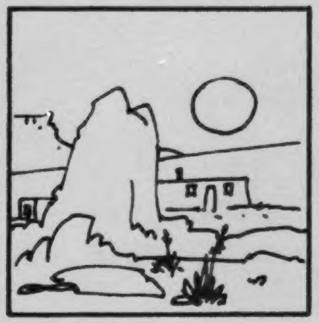
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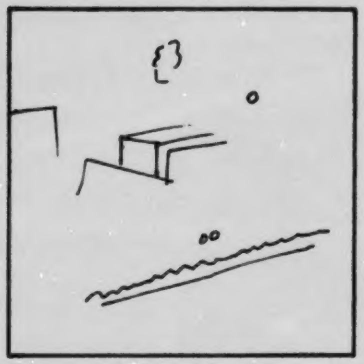
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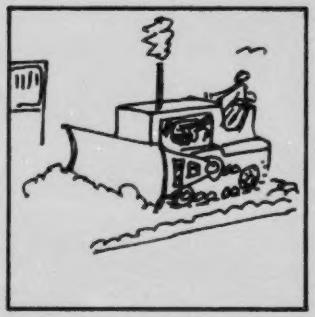
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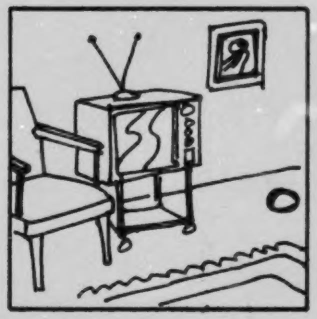
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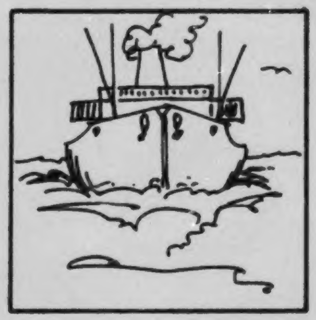
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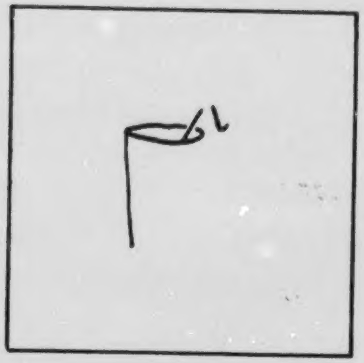
10. B

11. B

12. A



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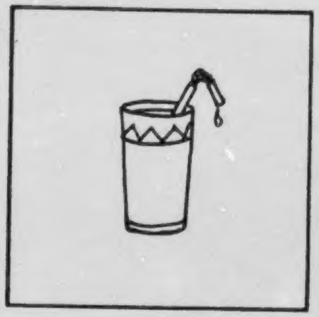

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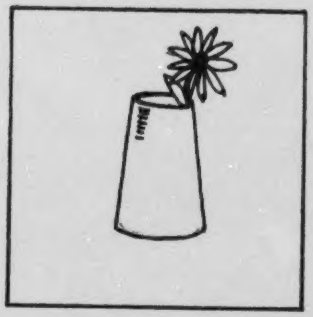

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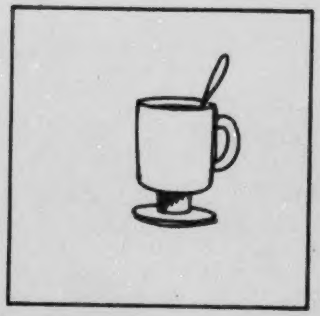

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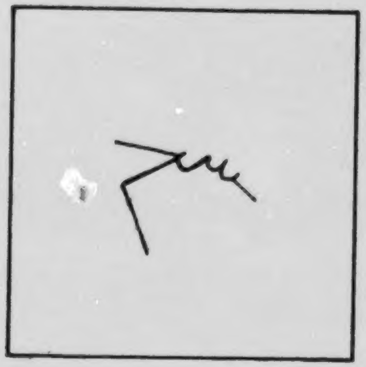

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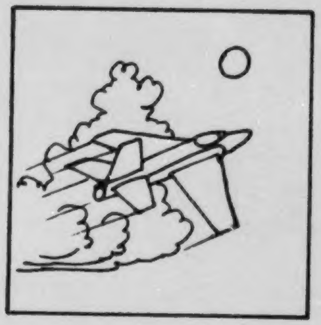

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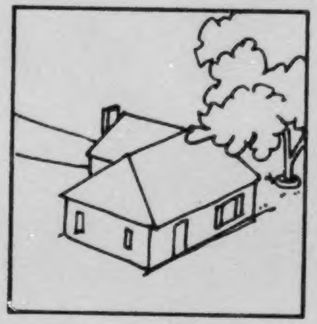

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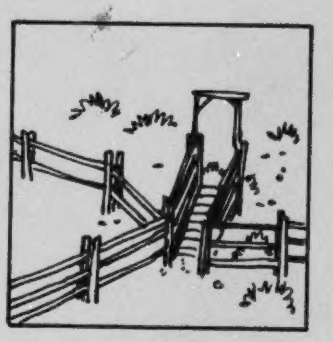

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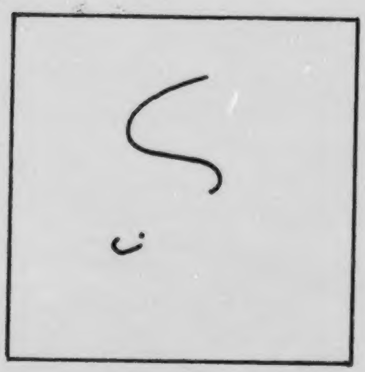

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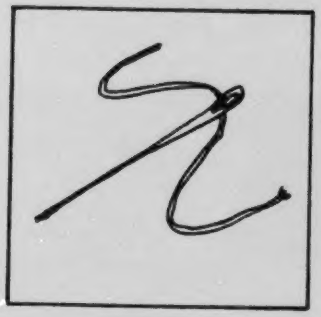

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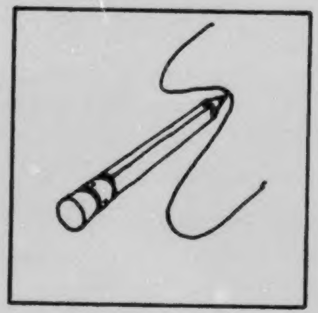

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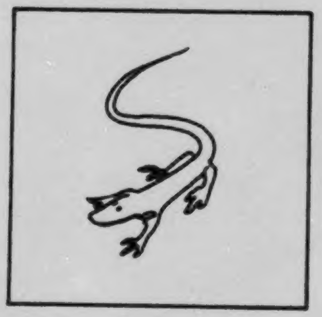
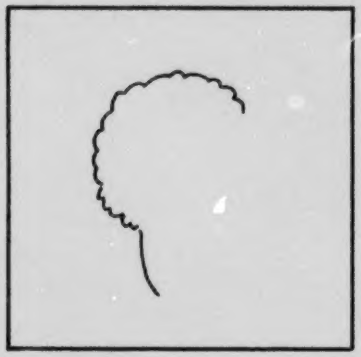


C.

13. A

14. B

15. C



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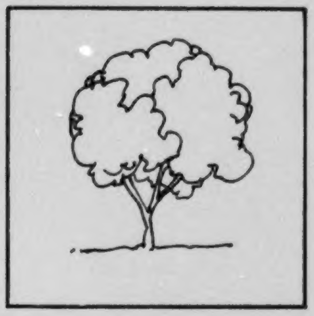

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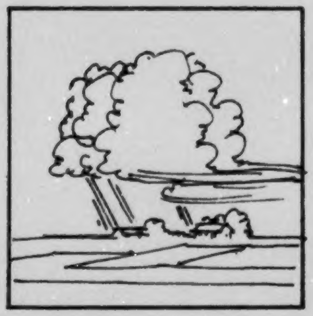

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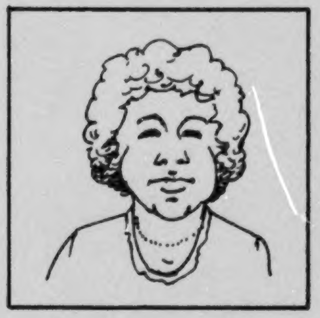

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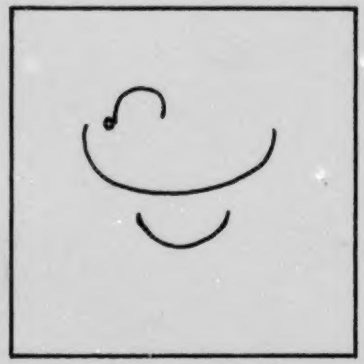

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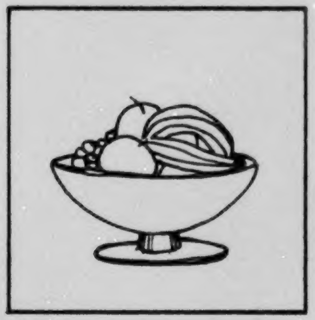

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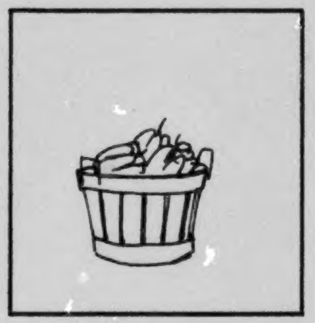

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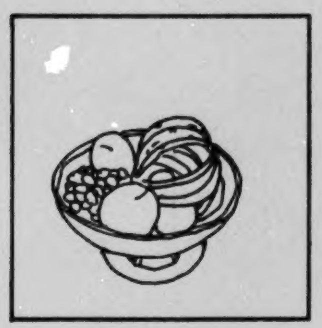

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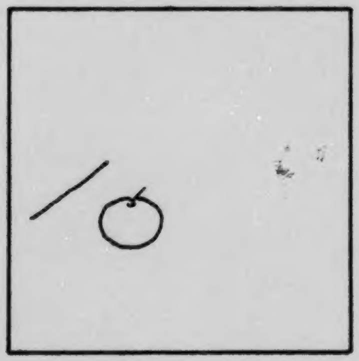

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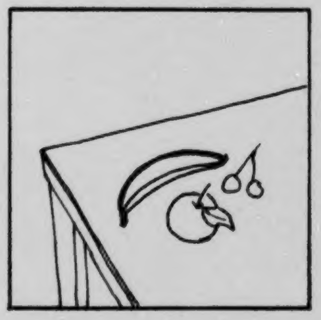

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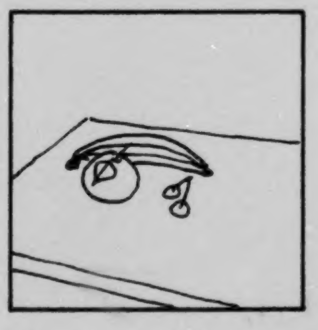

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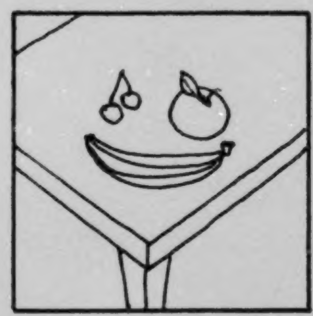
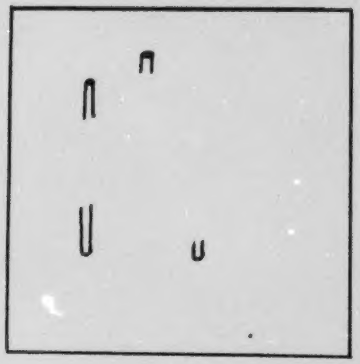


C.

16. C

17. C

18. B



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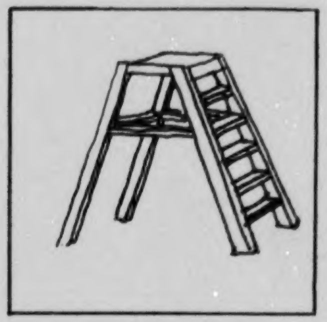

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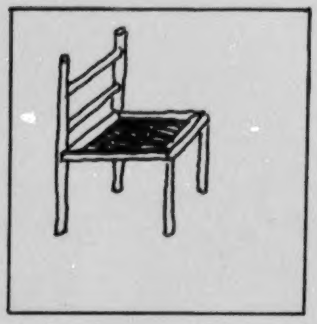

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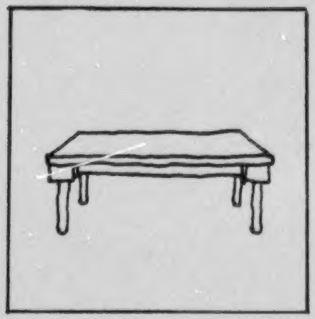

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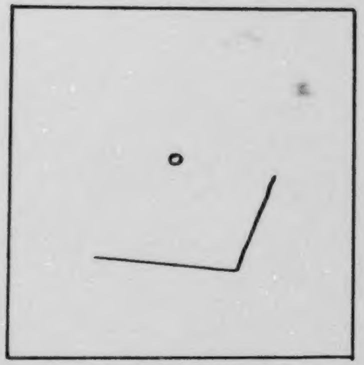

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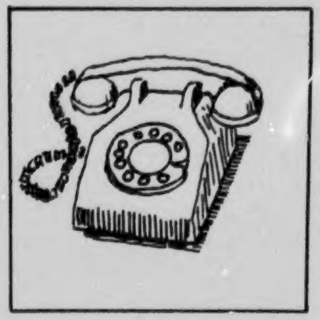

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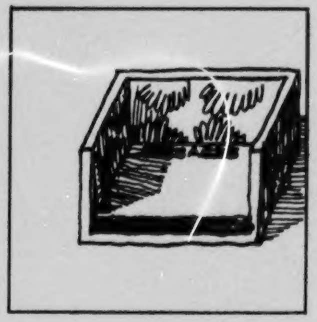

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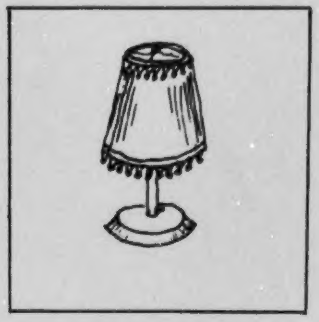

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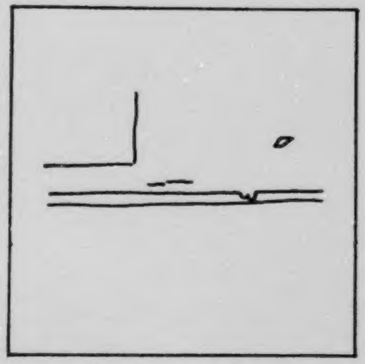

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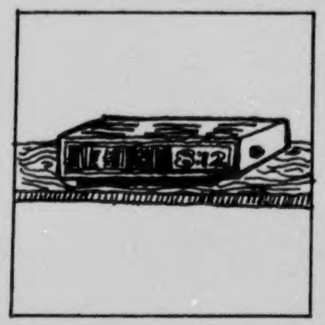

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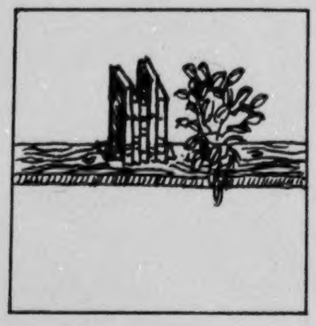

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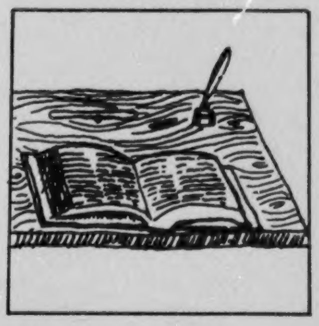
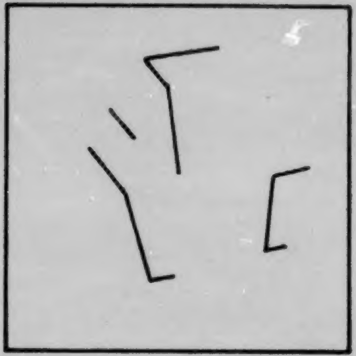


C.

19. B

20. A

21. B



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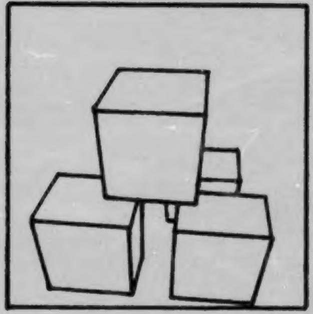

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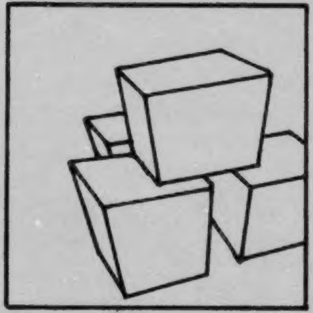

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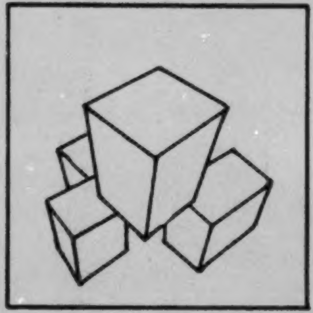

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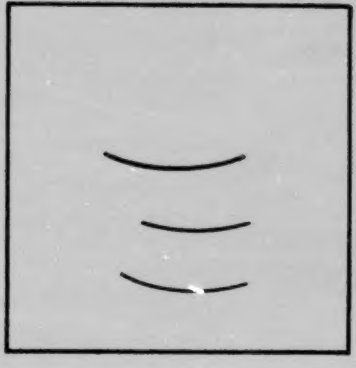

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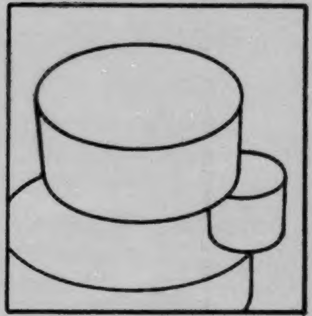

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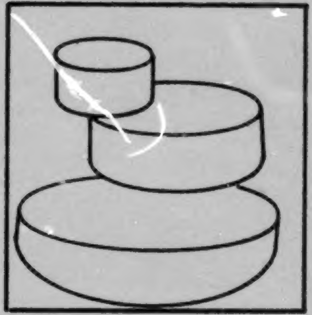

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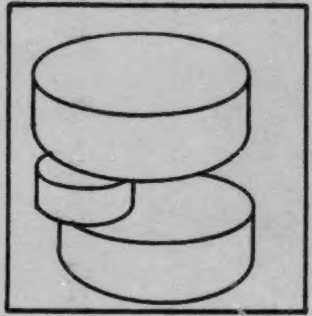

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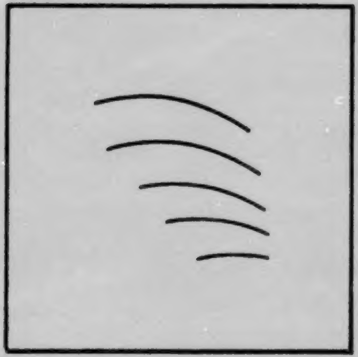

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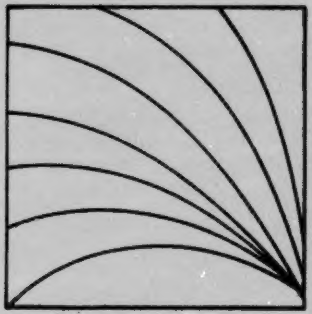

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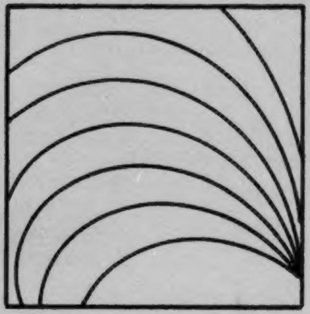

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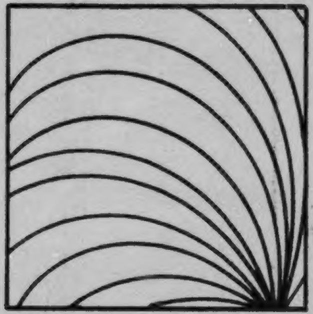
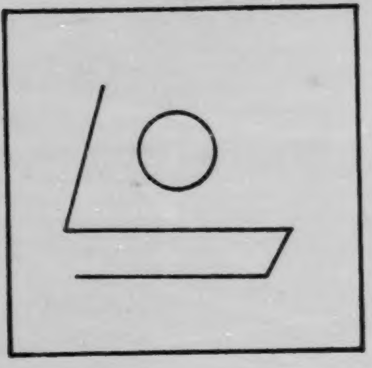


C.

22. B

23. C

24. B



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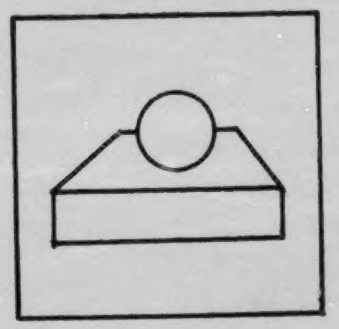

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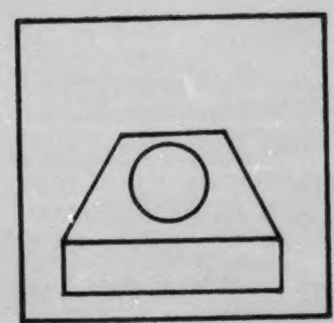

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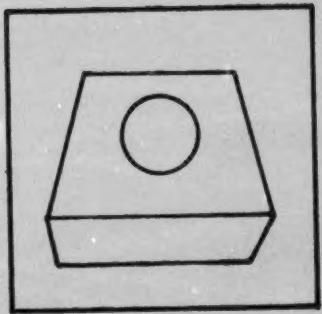

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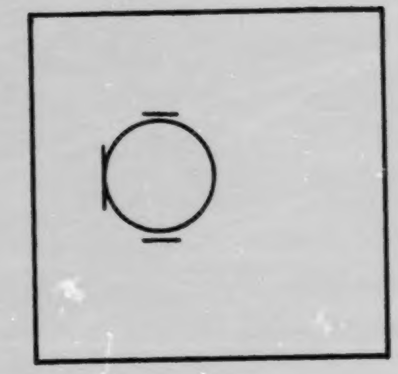

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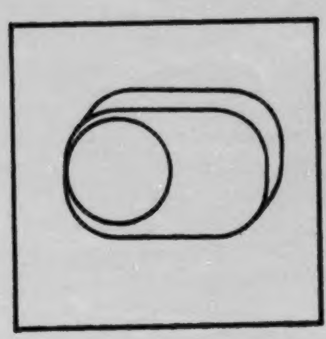

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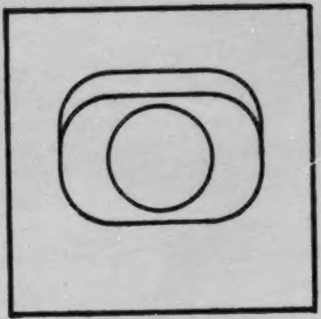

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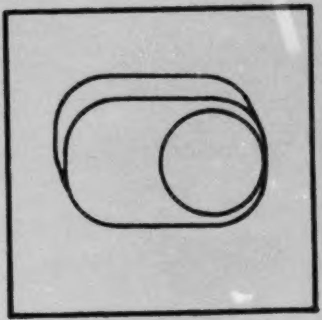

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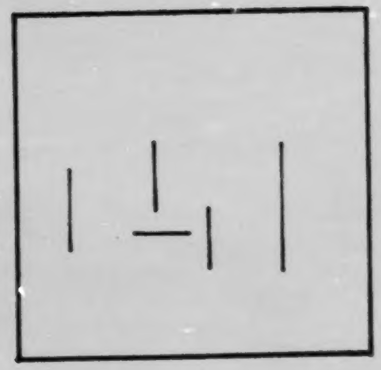

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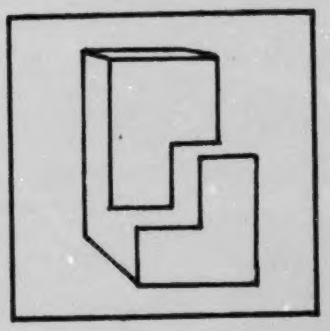

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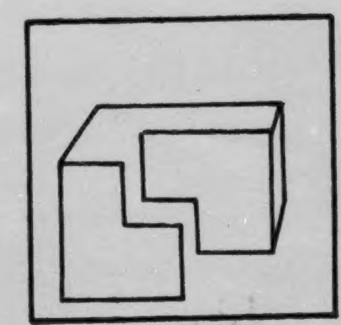

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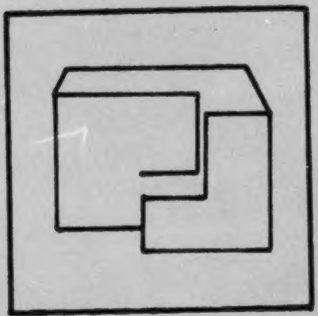
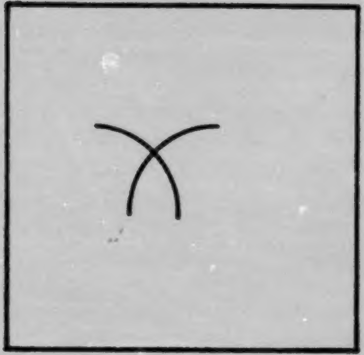


C.

25. C

26. A

27. B



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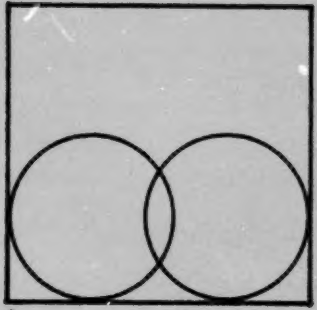

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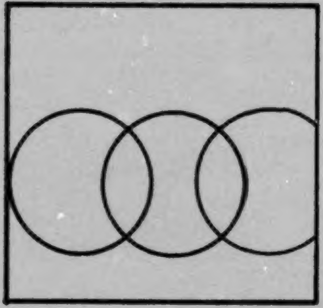

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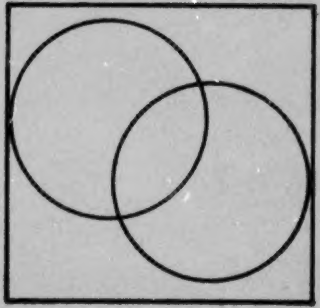

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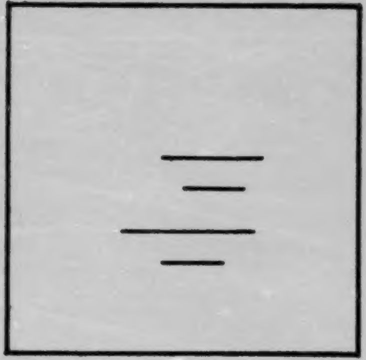

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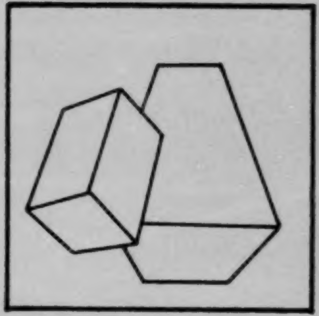

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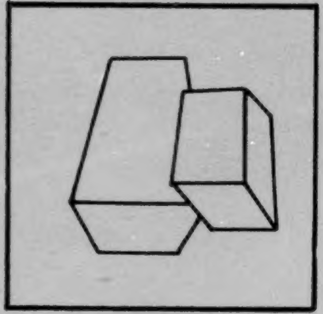

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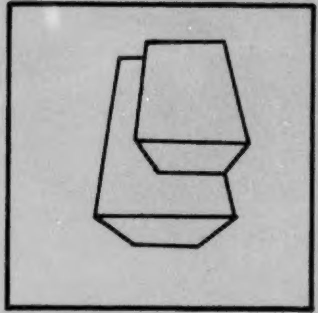

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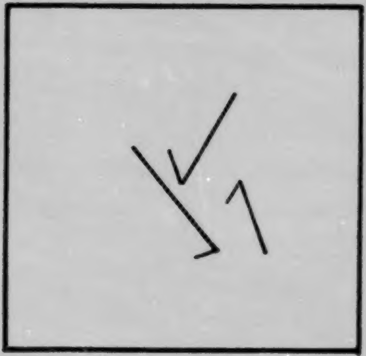

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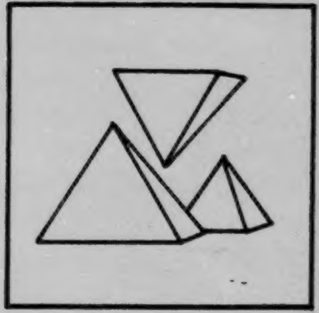

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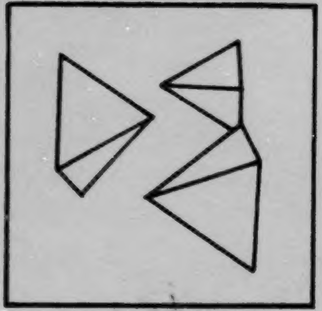

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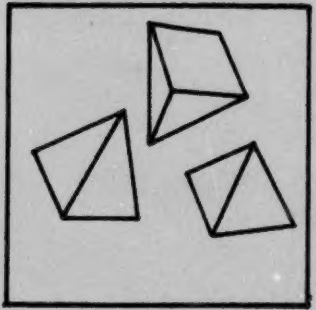


C.

28. B

29. C

30. A

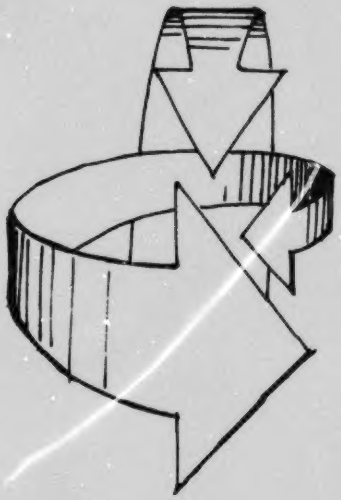
SOLUTIONS
FIGURE COMPLETION

1 [✓ A] B C
2 A [✓ B] C
3 [✓ A] B C
4 [✓ A] B C
5 A [✓ B] C
6 A B [✓ C]
7 A B [✓ C]
8 [✓ A] B C
9 A B [✓ C]
10 A [✓ B] C

11 A [✓ B] C
12 [✓ A] B C
13 [✓ A] B C
14 A [✓ B] C
15 A B [✓ C]
16 A B [✓ C]
17 A B [✓ C]
18 A [✓ B] C
19 A [✓ B] C
20 [✓ A] B C

21 A [✓ B] C
22 A [✓ B] C
23 A B [✓ C]
24 A [✓ B] C
25 A B [✓ C]
26 [✓ A] B C
27 A [✓ B] C
28 A [✓ B] C
29 A B [✓ C]
30 [✓ A] B C

Rotation I



ROTATION 1

OBJECTIVES

To rotate an abstract image mentally. To imagine the rotation of a pictured object.

DIRECTIONS

Look through the set of exercises. Notice that for those numbered 1 through 9, each page has a drawing in a box on the left-hand side of the page. Study the shape of the figure inside the box. Now, look at the box on the right-hand side of the page. The shape of the figure inside the two boxes is exactly the same. Can you turn Box B so that it looks like Box A? If so, answer yes on the sheet provided. Remember that you are mentally rotating the entire box, image and all, rather than just the image itself.

Exercises 10 through 27 ask you to rotate the box on the left-hand side of the page and to pick the box from the other four that will exactly match the rotated box.

If you answer all the exercises correctly, go to the set of exercises on *Rotation 2*. If some of your choices don't match the correct answers, you may want to try some of the additional exercises given under "What Else Can You Do?" on the next page. You may also want to copy the pages and cut out the box on the left and actually turn it to match the one on the right. As you do this, visualize the box turning. Close your eyes and try to see it.

APPLICATION

The ability to rotate objects mentally is required in many sports. Imagine how a baseball must rotate through space to land in the catcher's mitt. Or imagine how it feels when jumping off the high dive to do two complete rotations before hitting the water. You may also need to picture the movements of the earth and sun in order to determine where to plant a shade tree to cool your house in summer, or to determine how to sketch a room or greenhouse for a southern exposure.

This type of mental rotation applies to careers such as auto mechanics, aircraft mechanics, plumbing, electrical work, and television repair. Craftspeople project a mental image of the desired final arrangement of mechanical components and then work towards it. The ability to mentally rotate objects is also required in careers such as construction, engineering, astronomy, and geology.

ROTATION 1

WHAT ELSE CAN YOU DO?

Draw a three-dimensional object from several angles.

Fit left and right shoes into a shoebox.

Make stick figures of geometric shapes and turn them in space. Observe how they look as they turn. Or use Tinkertoys.

Use a miter box to cut angles on wood and fit the pieces together.

Look at any exhibit or photograph of a cross-section of a piece of machinery, a car, a jogging shoe, etc. Have a friend who understands cross-sectional drawings show you some good examples. Draw some yourself of a very familiar object such as a table leg or pencil.

Once you have the skill of mentally rotating entire objects, you will want to practice mentally moving the components of individual objects within the space. For example, imagine moving the furniture in a room. The room itself does not turn, but pieces of furniture may shift places and positions.

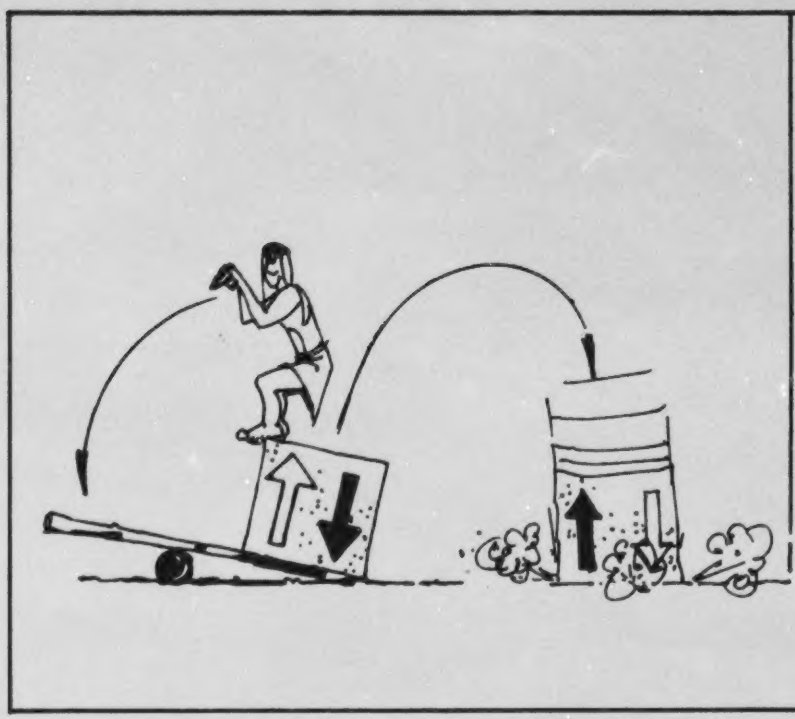
When playing chess or checkers, mentally project several moves in advance to determine if a given strategy will be successful.

LIST YOUR OWN IDEAS FOR IMPROVING YOUR ABILITY TO ROTATE OBJECTS IN SPACE MENTALLY

ANSWER SHEET

ROTATION 1

1	Yes	No	10	A	B	C	D	19	A	B	C	D
2	Yes	No	11	A	B	C	D	20	A	B	C	D
3	Yes	No	12	A	B	C	D	21	A	B	C	D
4	Yes	No	13	A	B	C	D	22	A	B	C	D
5	Yes	No	14	A	B	C	D	23	A	B	C	D
6	Yes	No	15	A	B	C	D	24	A	B	C	D
7	Yes	No	16	A	B	C	D	25	A	B	C	D
8	Yes	No	17	A	B	C	D	26	A	B	C	D
9	Yes	No	18	A	B	C	D	27	A	B	C	D



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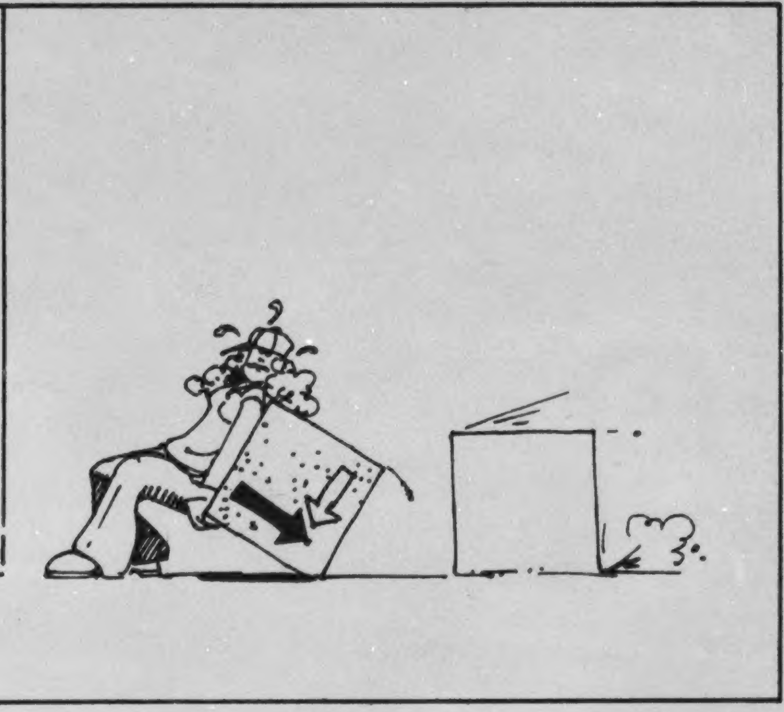

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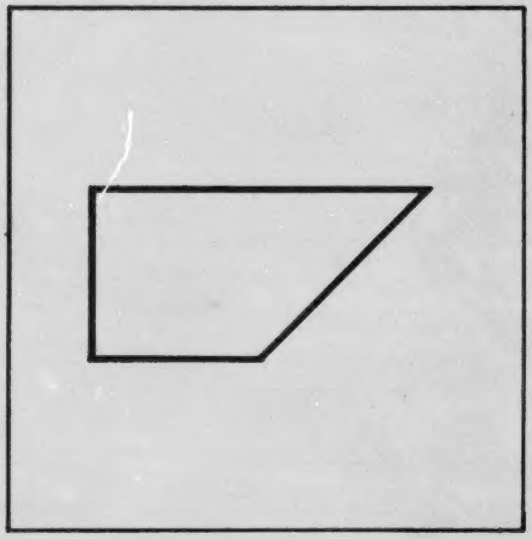
1. LOOK AT THE TWO PICTURES BELOW. CAN YOU TURN THE SECOND BOX (B) SO THAT IT LOOKS LIKE THE FIRST BOX? IS B A ROTATION OF A? CIRCLE YES or NO ON YOUR ANSWER SHEET.



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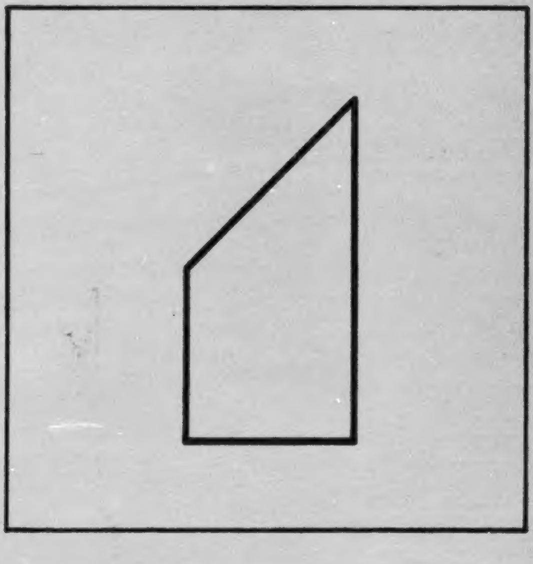
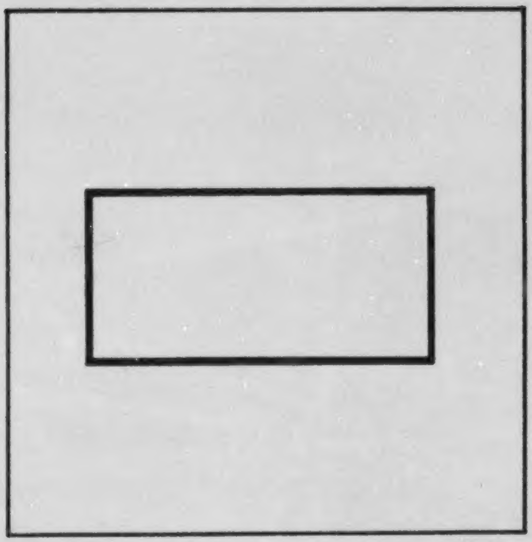


B.

NOW, CONTINUE IN THE SAME WAY ...

2.



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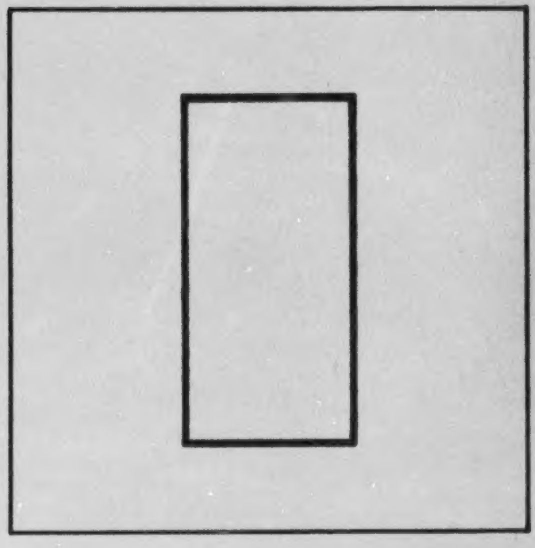

B.

CONTINUE ▷

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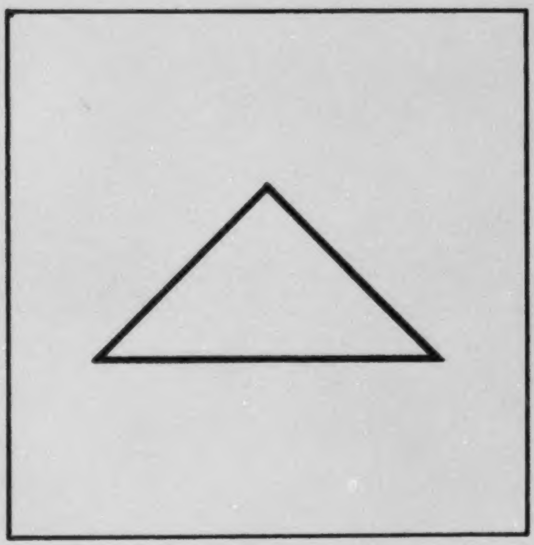
6.



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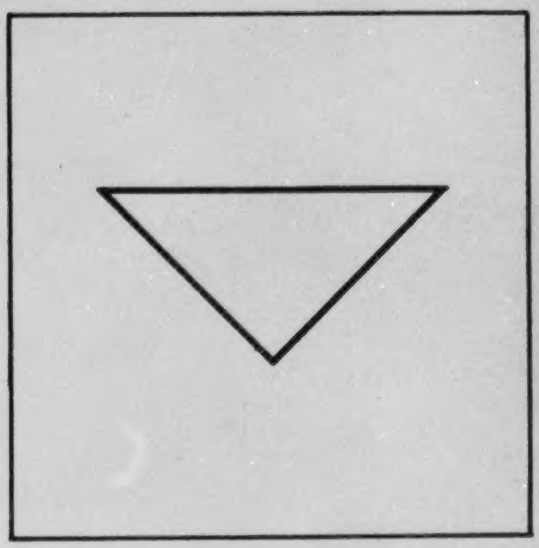
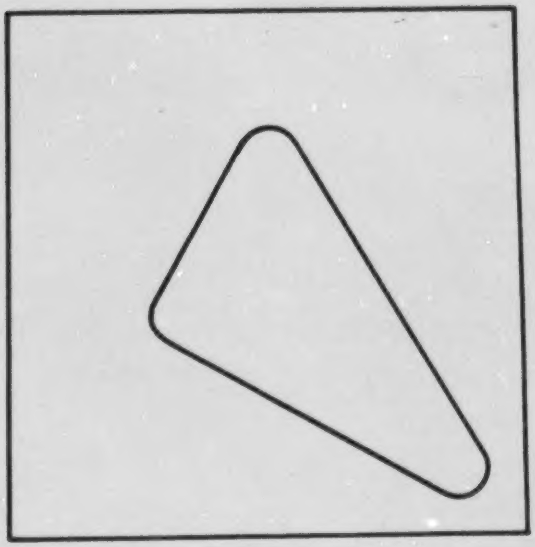


B.

CONTINUE ▷

4.



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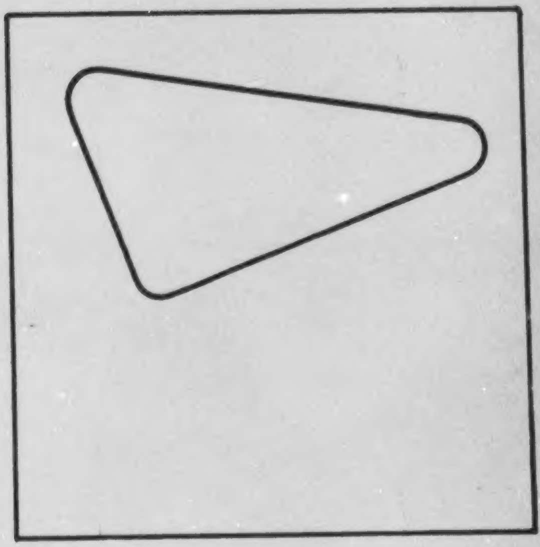
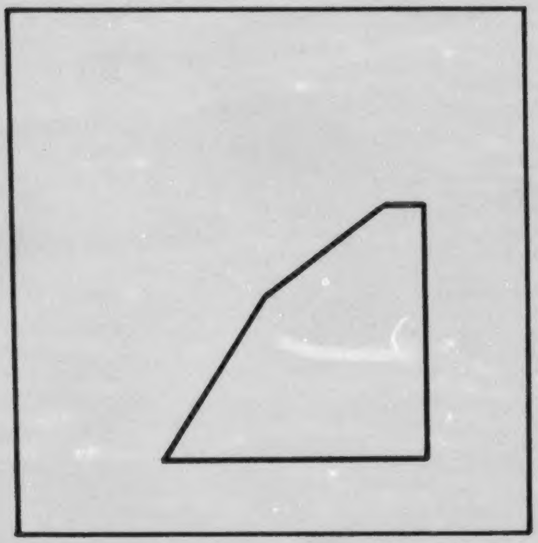


B.

CONTINUE ▷



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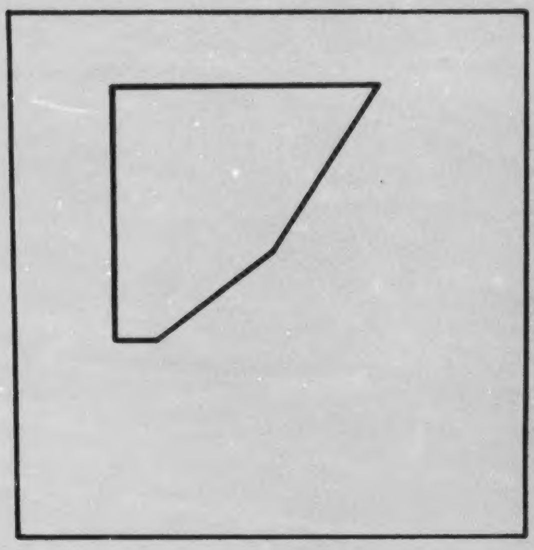
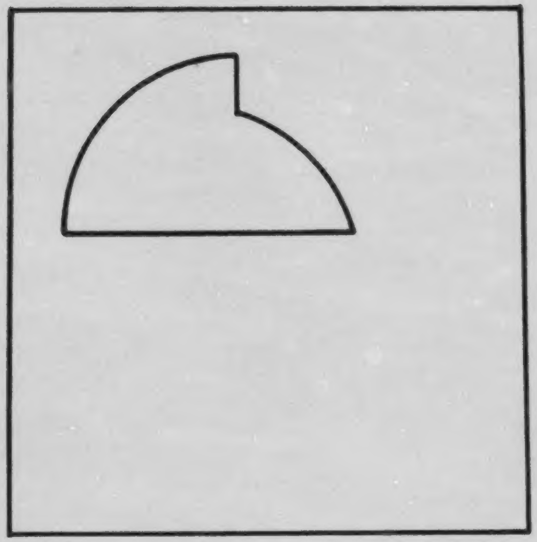


B.

CONTINUE ▷

149



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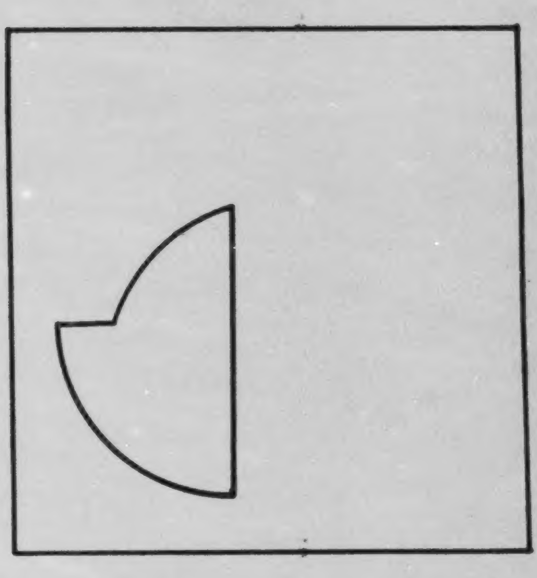
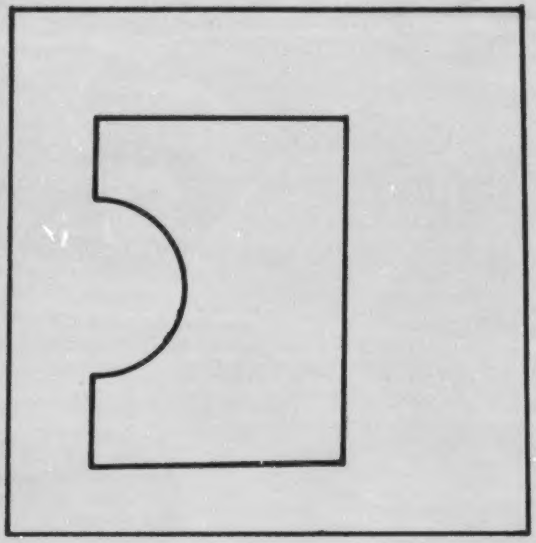


B.

CONTINUE ▷



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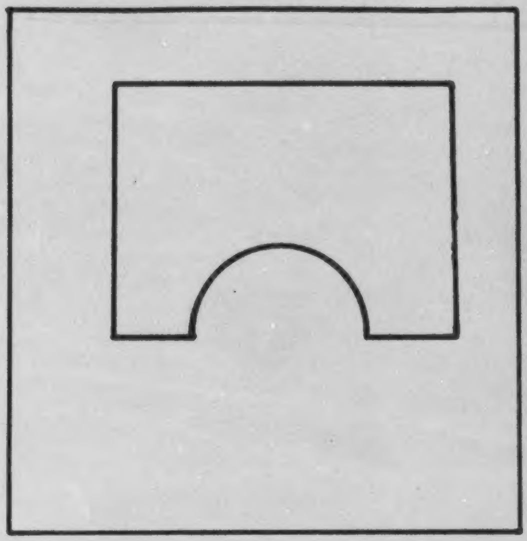

B.

CONTINUE ▷

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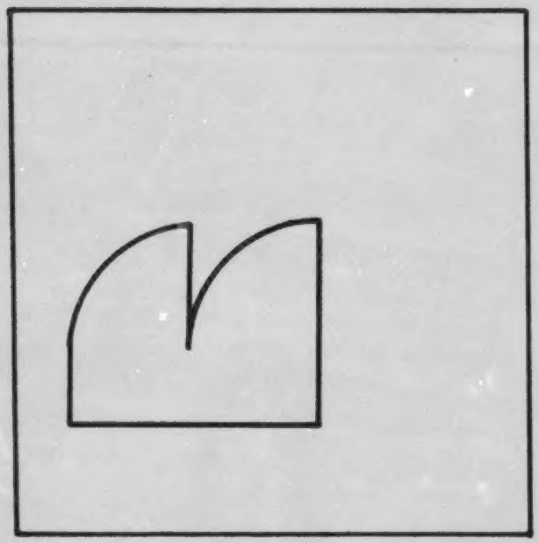
3.



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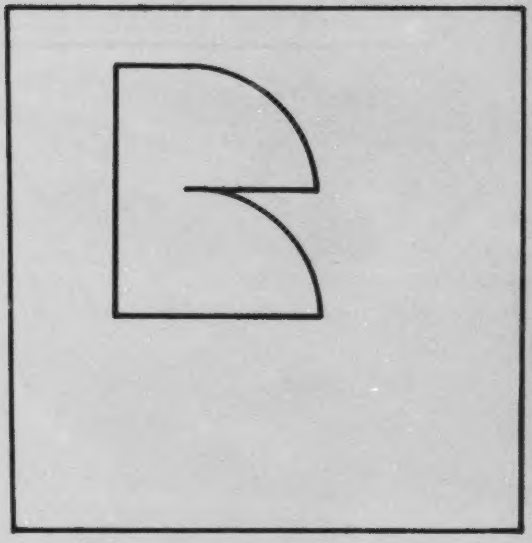
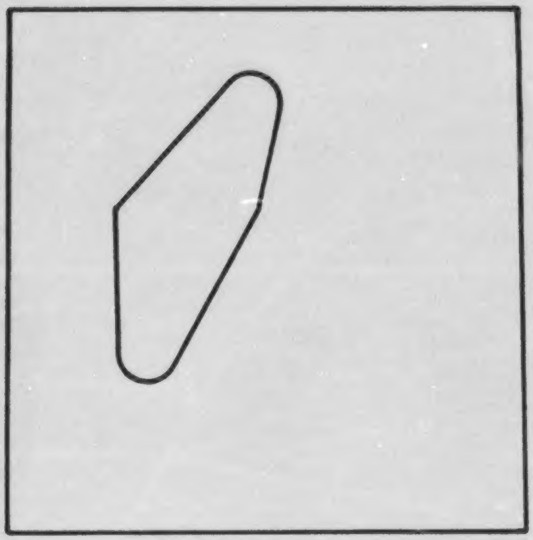


B.

CONTINUE ▷



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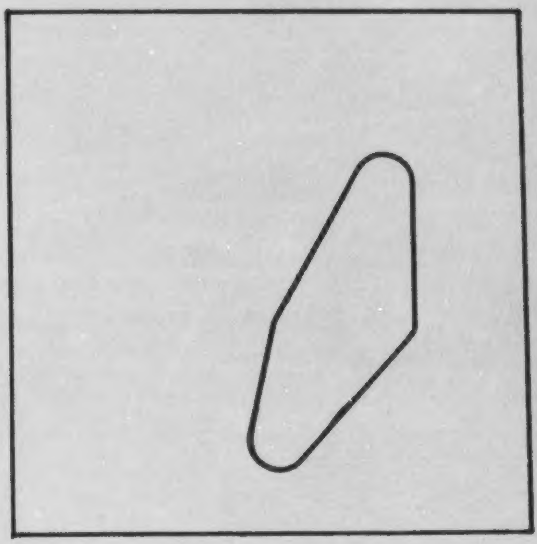

B.

CONTINUE ▷

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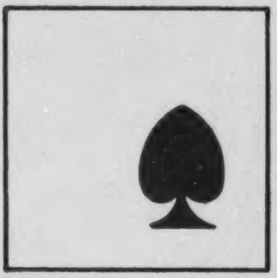
ON THE LEFT SIDE OF THE PAGE IS A BOX LABELED 10. IT HAS AN OBJECT IN IT. ON THE RIGHT ARE FOUR BOXES LABELED A, B, C, & D. PICK THE BOX THAT WILL EXACTLY MATCH NUMBER 10 WHEN IT IS ROTATED. NOW DO THE SAME FOR NUMBER 11.



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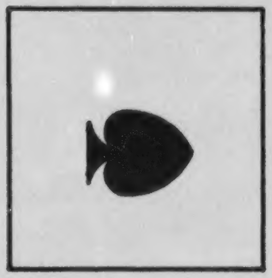

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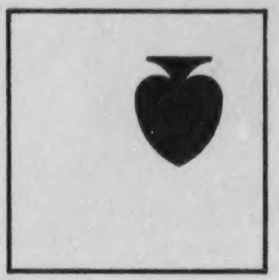

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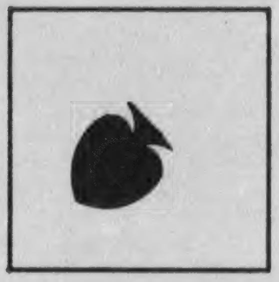

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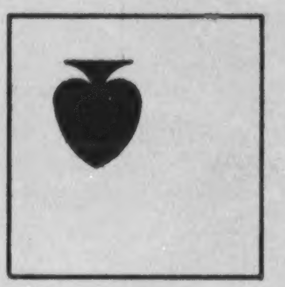

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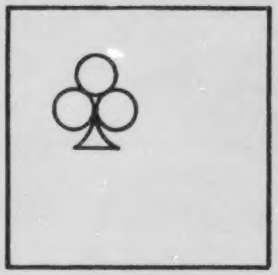
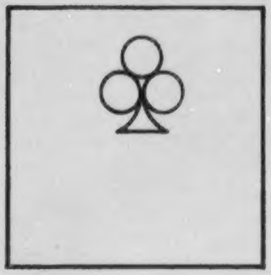


11.



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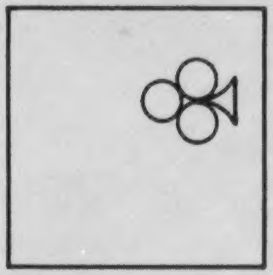
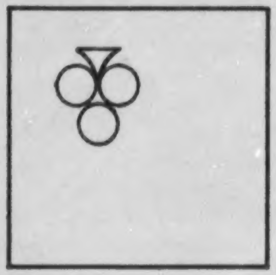


B.



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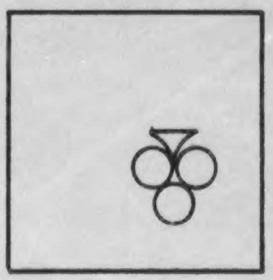
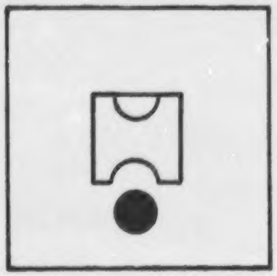


D.

10. D

11. D

PICK THE BOXES THAT WILL EXACTLY MATCH NUMBERS 12 AND 13
WHEN THEY ARE ROTATED.



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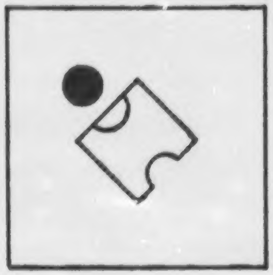

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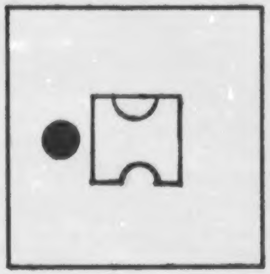

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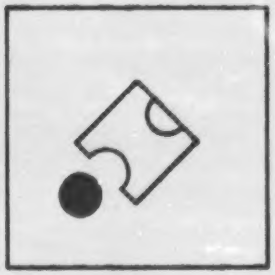

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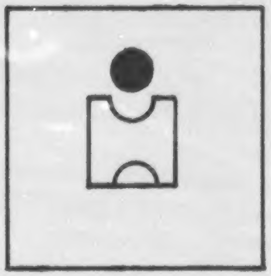

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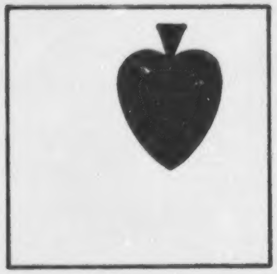

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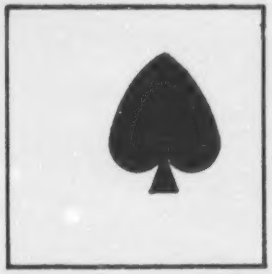

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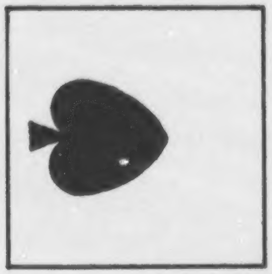

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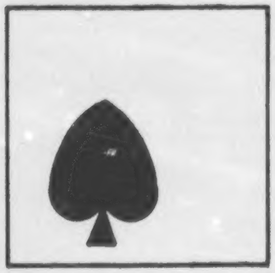

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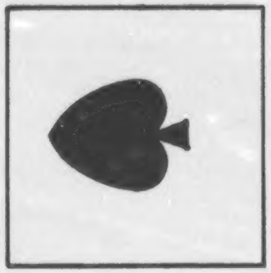
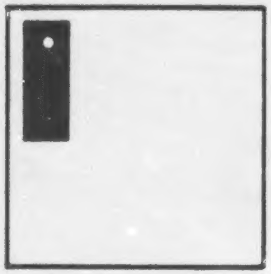


D.

12. D

13. C

AGAIN, CHOOSE THE BOXES THAT WILL EXACTLY MATCH NUMBERS 14 AND NUMBER 15 WHEN THEY ARE ROTATED.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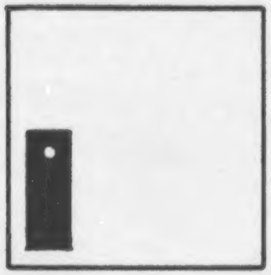
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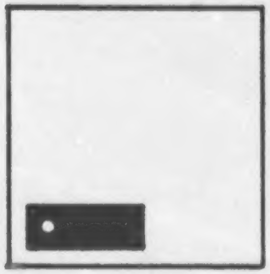
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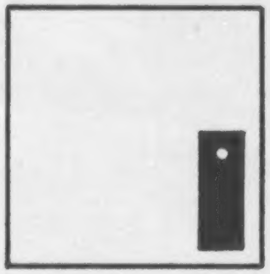
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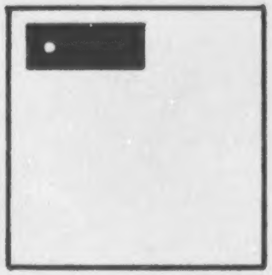
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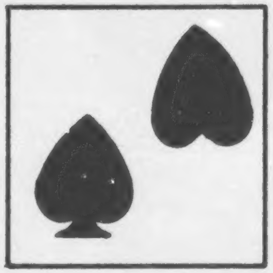
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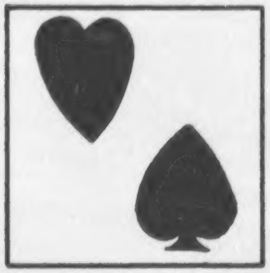
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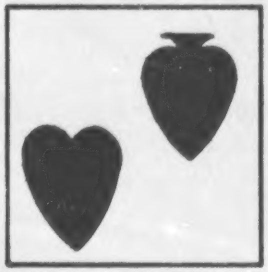
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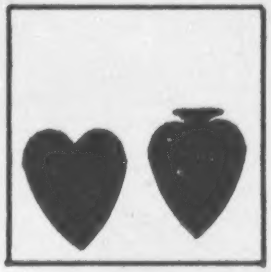
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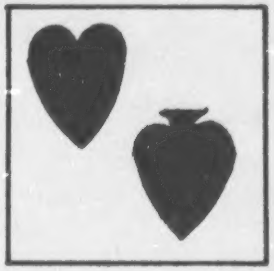
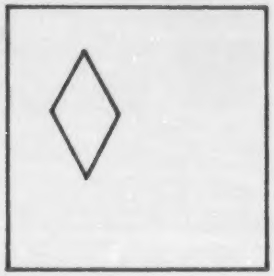

D.

14. B

15. B



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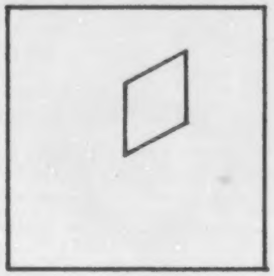

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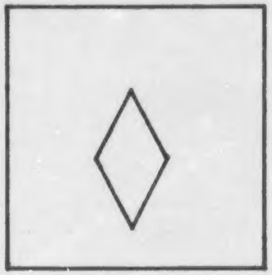

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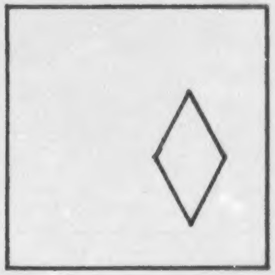

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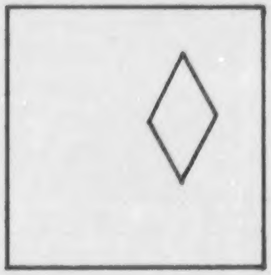

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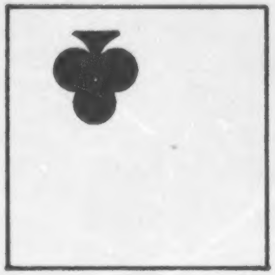

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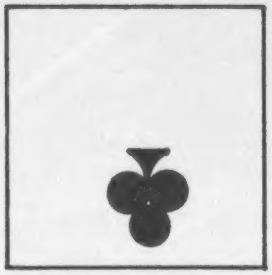

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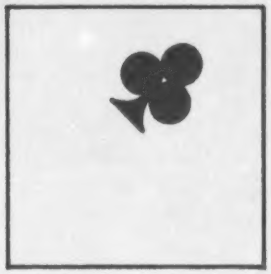

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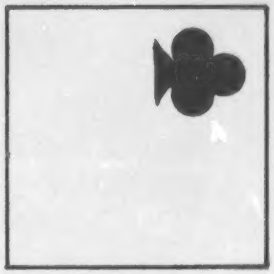

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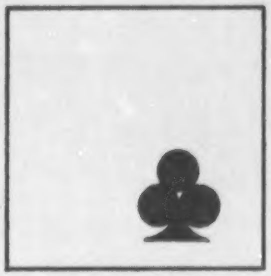

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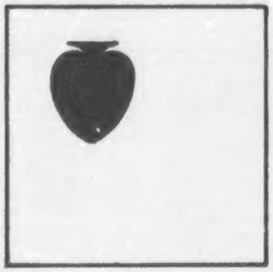

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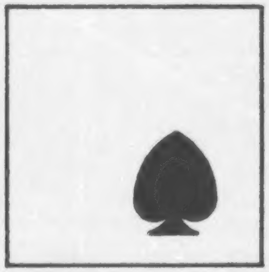

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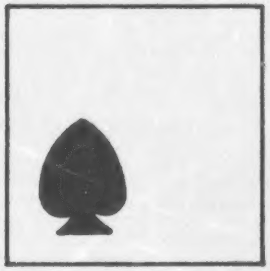

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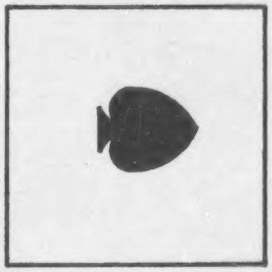

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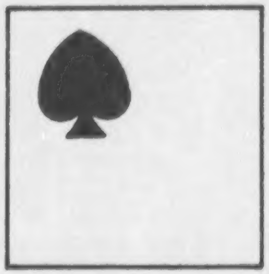
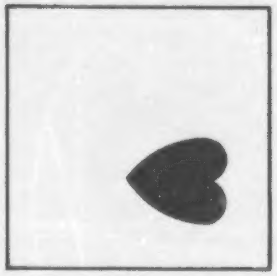


D.

16. C

17. D

18. A



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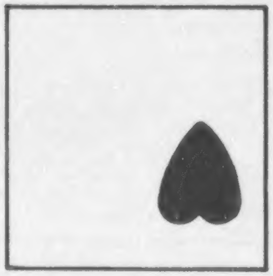

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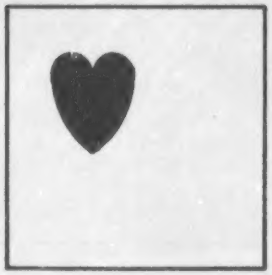

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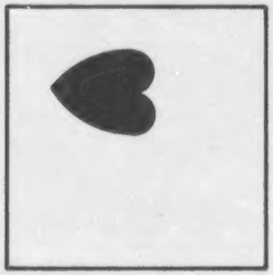

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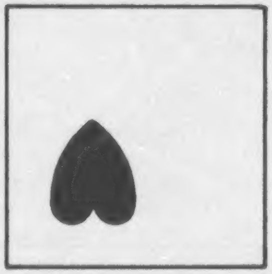

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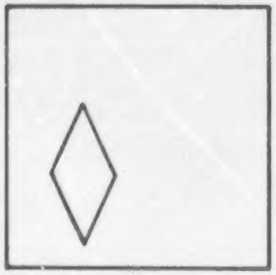

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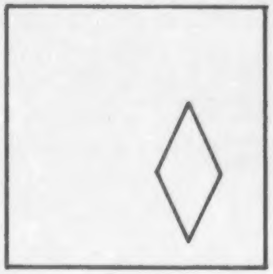

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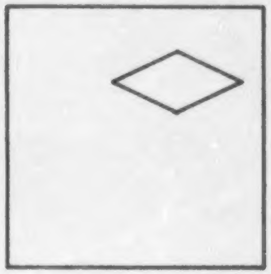

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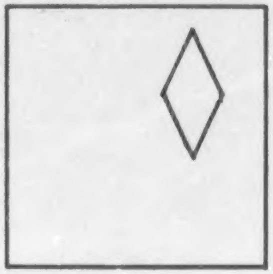

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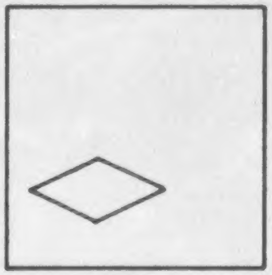

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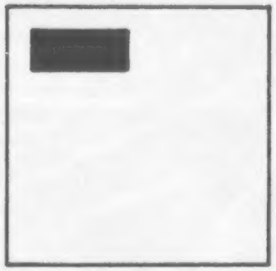

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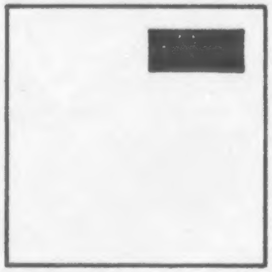

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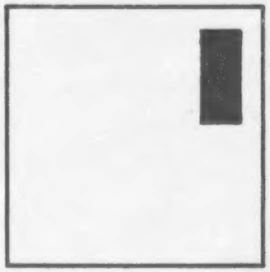

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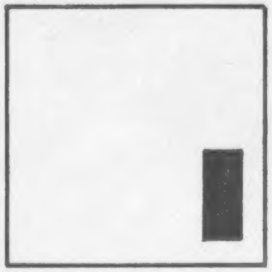

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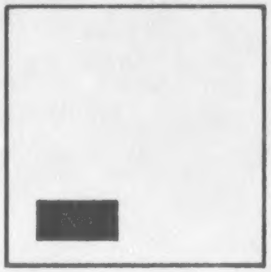
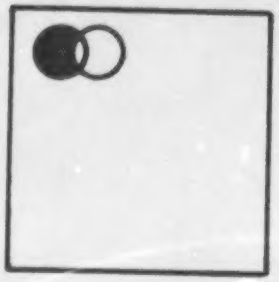


D.

19. D

20. C

21. B



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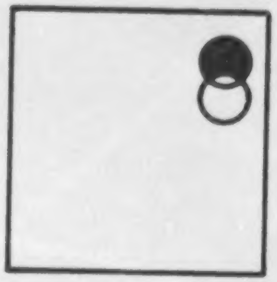

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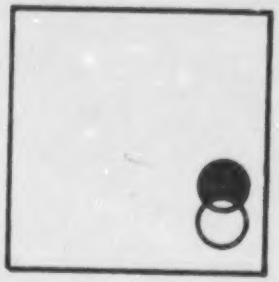

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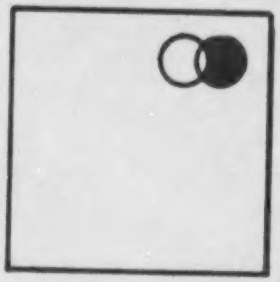

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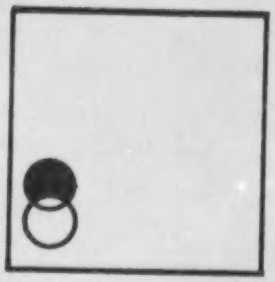

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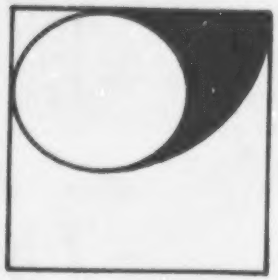

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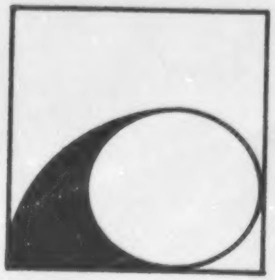

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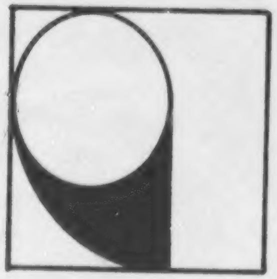

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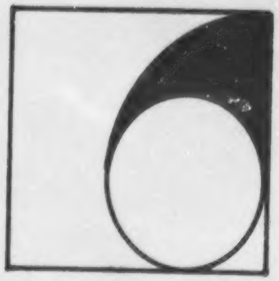

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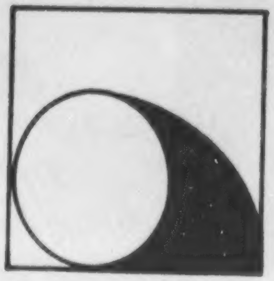

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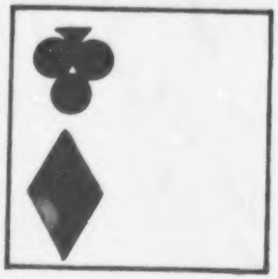

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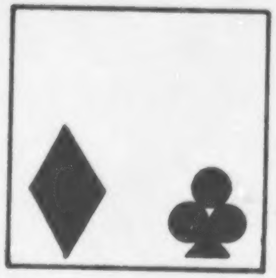
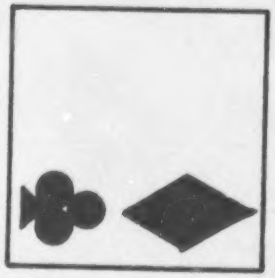


A.



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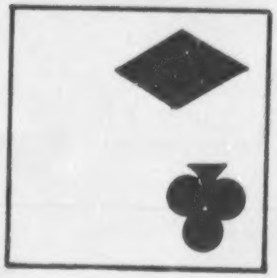

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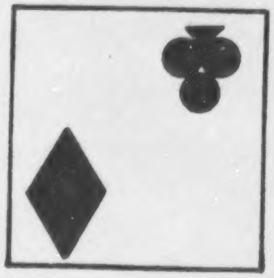
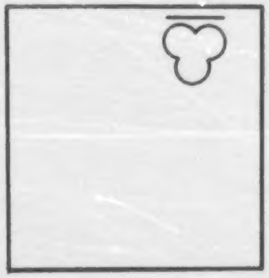


D.

22. A

23. A

24. B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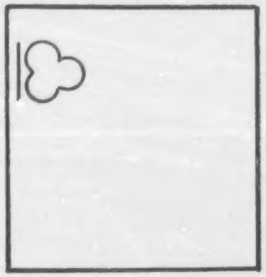
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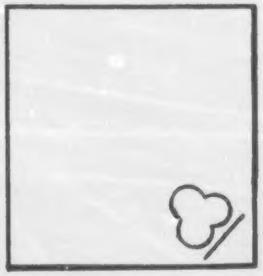
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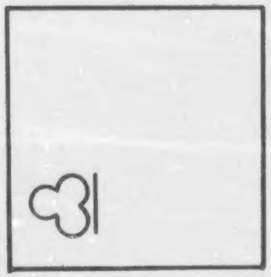
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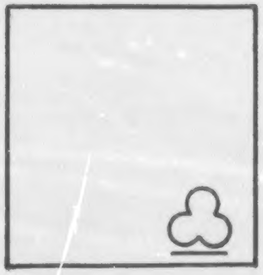
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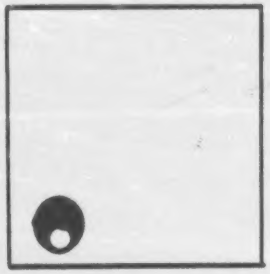
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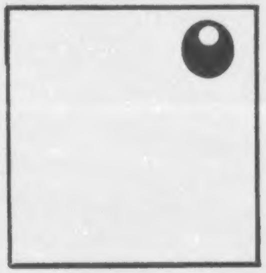
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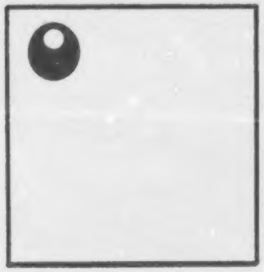
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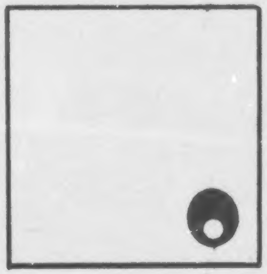
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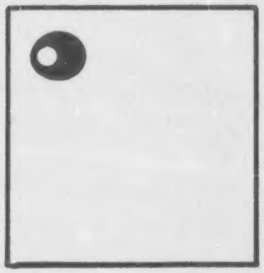
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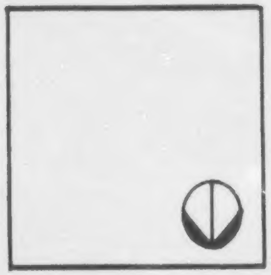
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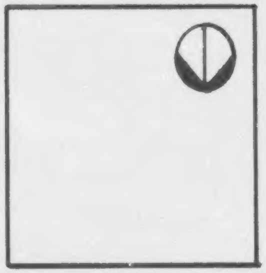
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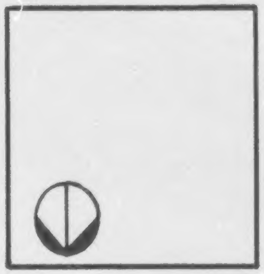
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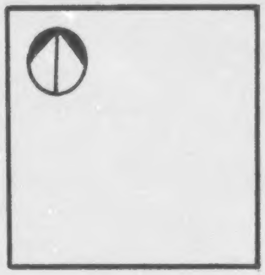
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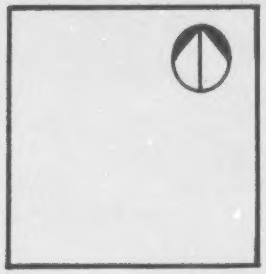

D.

25. A

26. A

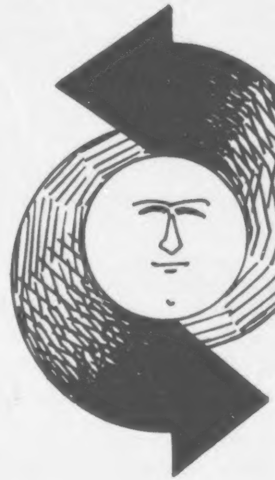
27. C

SOLUTIONS
ROTATION 1

1 Yes [✓ No]
2 [✓ Yes] No
3 [✓ Yes] No
4 Yes [✓ No]
5 [✓ Yes] No
6 [✓ Yes] No
7 Yes [✓ No]
8 [✓ Yes] No
9 [✓ Yes] No

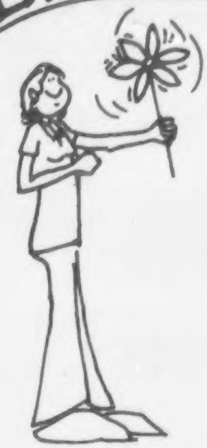
10 A B C [✓ D]
11 A B C [✓ D]
12 A B C [✓ D]
13 A B [✓ C] D
14 A [✓ B] C D
15 A [✓ B] C D
16 A B [✓ C] D
17 A B C [✓ D]
18 [✓ A] B C D

19 A B C [✓ D]
20 A B [✓ C] D
21 A [✓ B] C D
22 [✓ A] B C D
23 [✓ A] B C D
24 A [✓ B] C D
25 [✓ A] B C D
26 [✓ A] B C D
27 A B [✓ C] D



Rotation 2

ROTATION 2



OBJECTIVE

To imagine the rotation of an object about a point.

DIRECTIONS

These activities ask you to look at an object and to imagine it turning. As you mentally turn it, you must keep the details inside the object in the same place as they were in the original drawing. The center will remain in place as the rest of the drawing turns about it. It is similar to a windmill or the pinwheel being held by the cartoon character on the left.

Look through the activities. Imagine the circle on the left turning. Will it look like the circle on the right after it has been turned? If so, answer yes on the sheet provided.

If you answer all the exercises correctly, go to the set of activities on *Spatial Memory and Rotation*. But, if some do not match, try copying the pages and cutting out the circle on the left. Turn it slowly until you think it matches the circle on the right. Then try to imagine the circle turning without actually doing so.

Additional exercises are suggested under "What Else Can You Do?"

APPLICATION

The ability to rotate an object mentally about a point is required in abstract thinking. You must think of the center point as being fixed with space moving about it. Most examples of rotation about a point are those that occur in nature, rather than something you do yourself. The skill of visualizing the rotation of an object, however, is necessary for other types of visual thinking. In particular, this type of ability is required for careers using mathematics.

WHAT ELSE CAN YOU DO?

Use a compass to draw circles.

Watch a dancer as he or she turns. Notice how they spot by keeping their eyes on one point.

Imagine a merry-go-round turning. Visualize yourself on it. As you spin, what happens to the rest of the merry-go-round?

Watch a bicycle wheel as it turns.

Draw your own examples.

Visualize the way the threads of a screw turn and the direction they must go.

Look at a set of gears. Visualize how each gear must turn in order for the total set to function.

Play a game that has a target that spins, such as darts with a spinning board. Watch the board carefully. Try to visualize where parts of the target will be in relation to the center point.

LIST YOUR OWN IDEAS TO IMPROVE YOUR ABILITY TO ROTATE OBJECTS MENTALLY

ANSWER SHEET
ROTATION 2

1 Yes No

2 Yes No

3 Yes No

4 Yes No

5 Yes No

6 Yes No

7 Yes No

8 Yes No

9 Yes No

10 Yes No

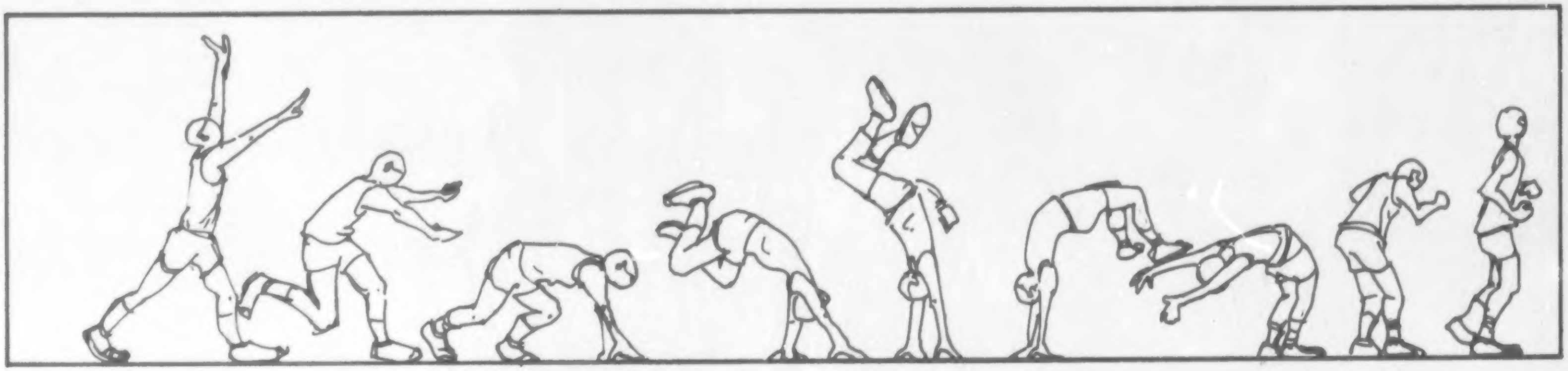
11 Yes No

12 Yes No

13 Yes No

14 Yes No

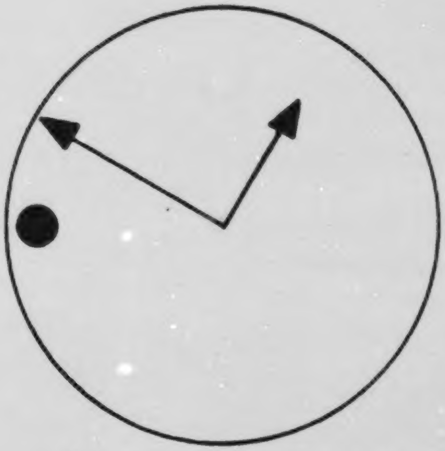
15 Yes No



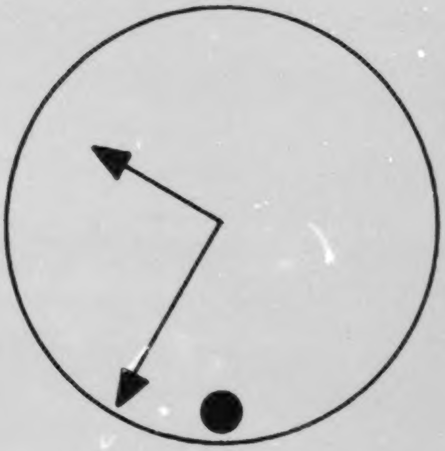
137

188

1. LOOK AT THE TWO DRAWINGS BELOW. IS B A ROTATION OF A? CIRCLE YES OR NO ON YOUR ANSWER SHEET.



A.



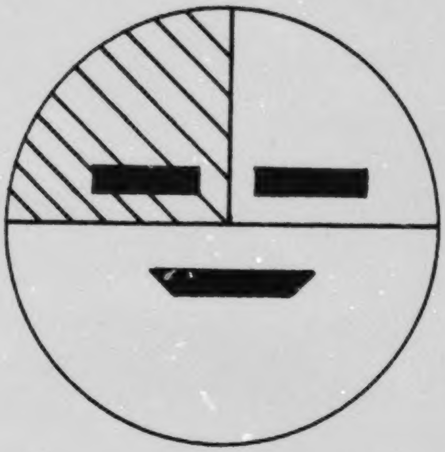
B.

NOW, GO ON TO THE NEXT DRAWING. CONTINUE TO MARK YES ON YOUR ANSWER SHEET IF B IS A ROTATION OF A.

▷

190

2. IS B A ROTATION OF A ?



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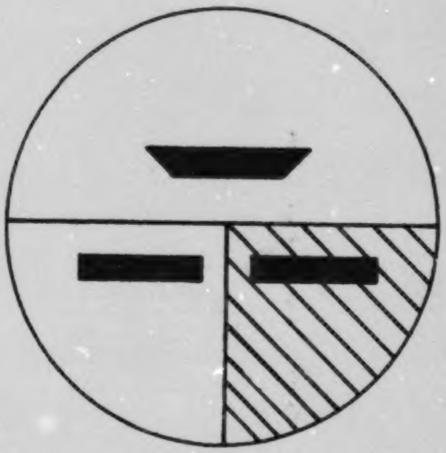
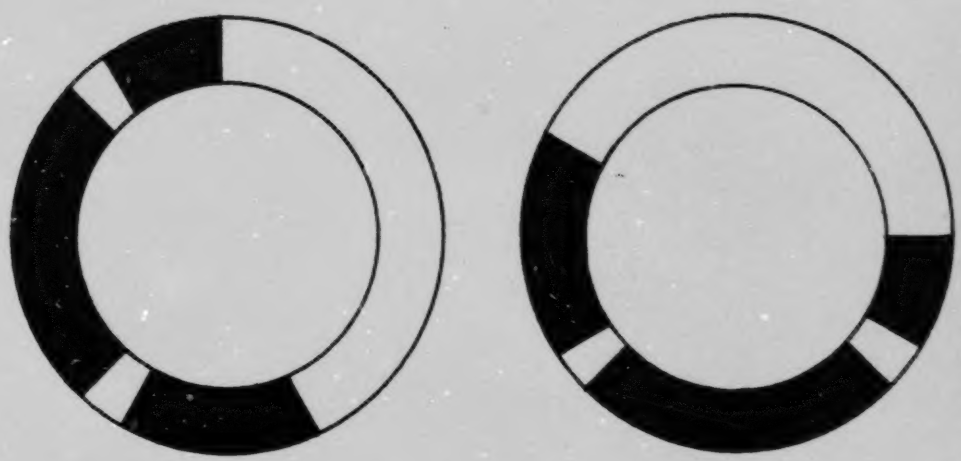


B.

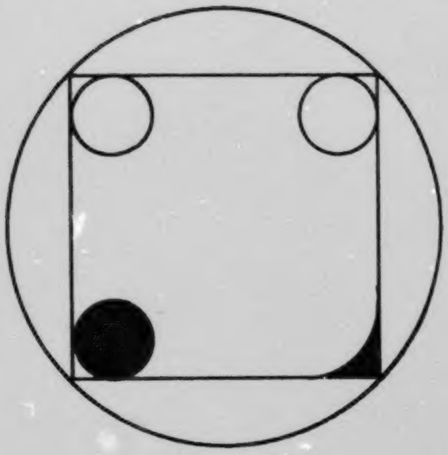
3.



A. B.

194

4.



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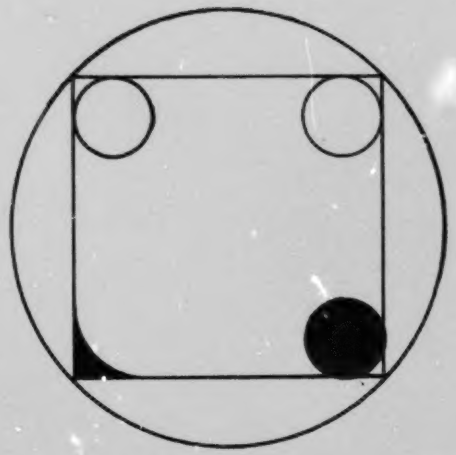
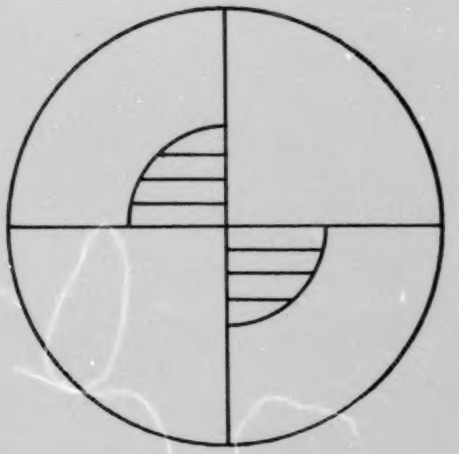


B.

. No

5.



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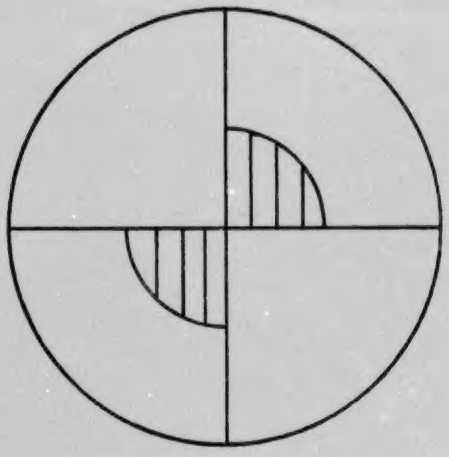

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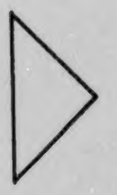
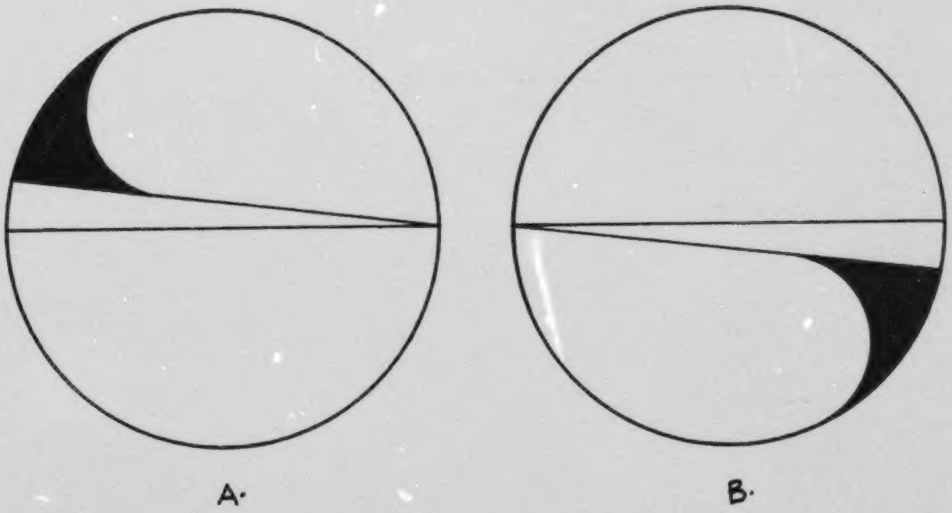


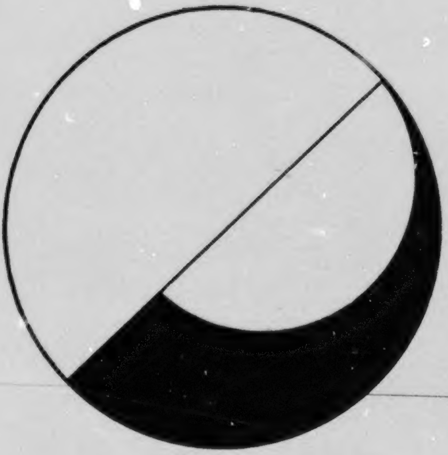
. Yes

6.



Yes

7.



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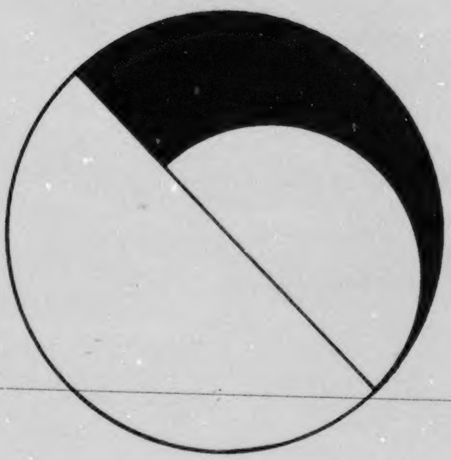
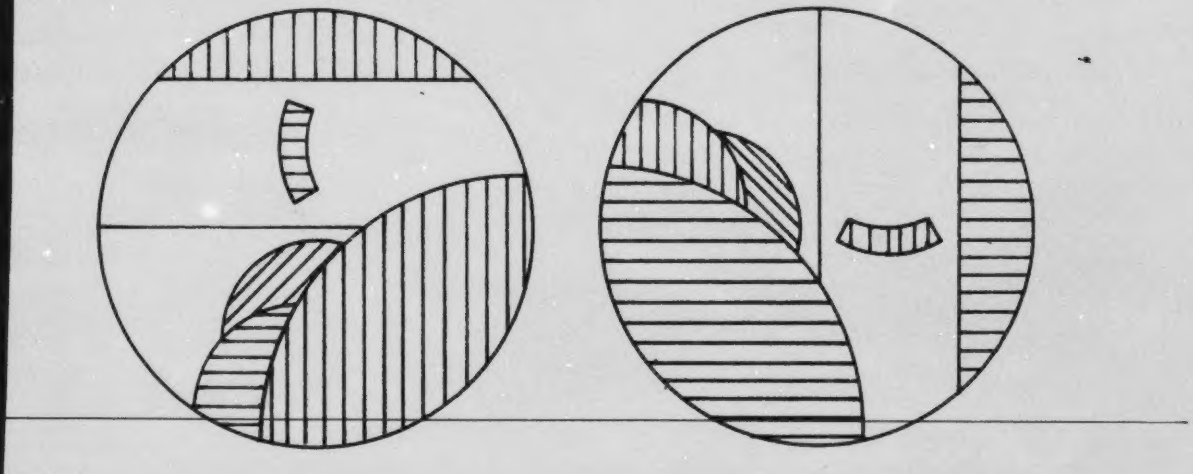


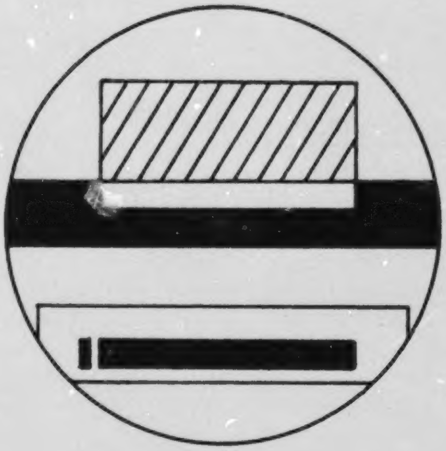
B.

No

202


A.
B.

3. No



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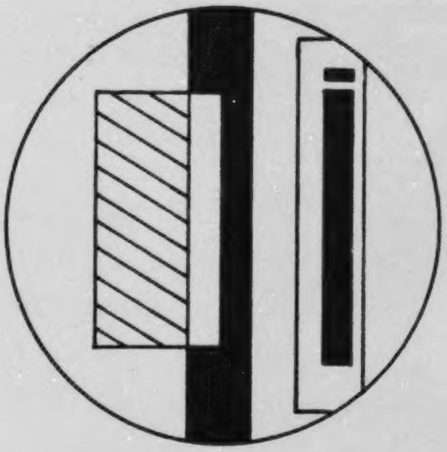
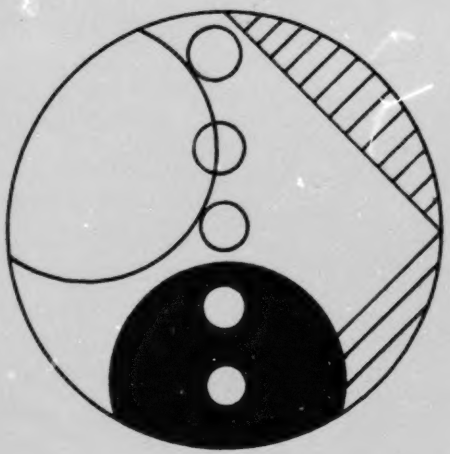


B.

No

206

10·



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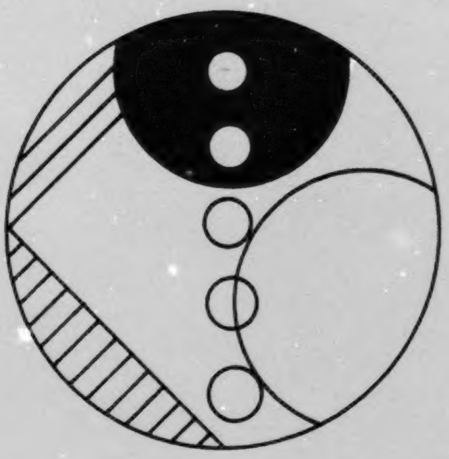


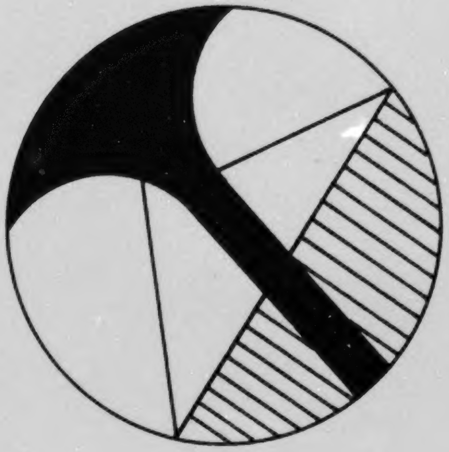
B·

207

Yes

208

11·



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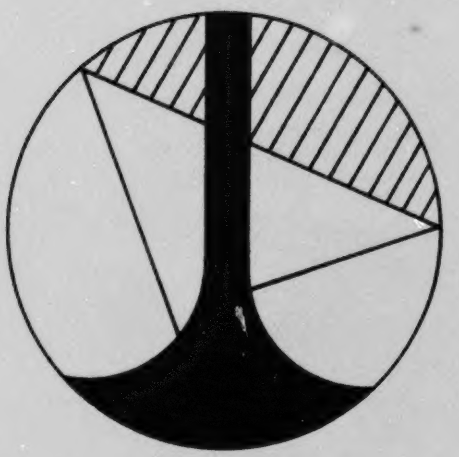


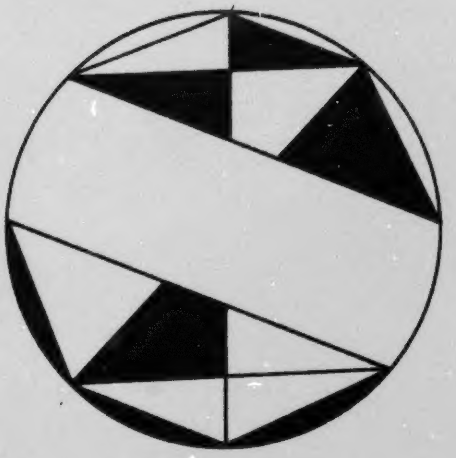
B.

209

No

210

12.



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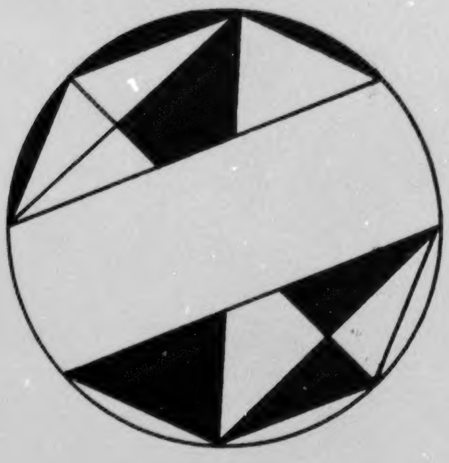
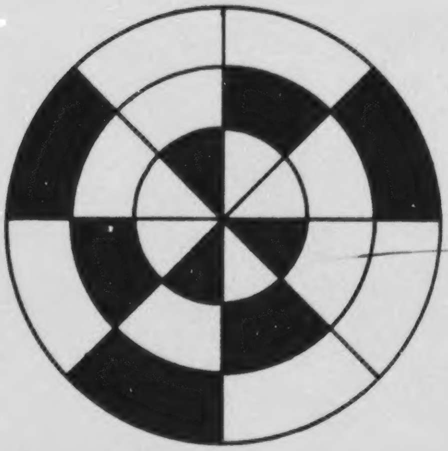


B.

Yes

212

13.



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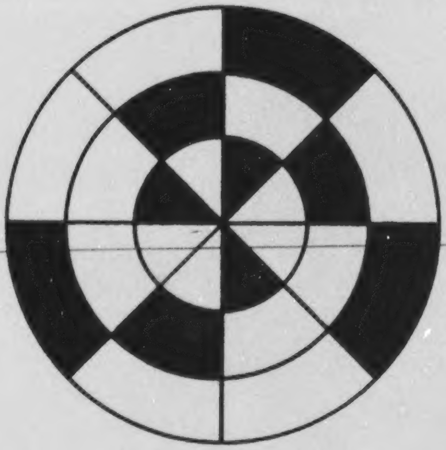
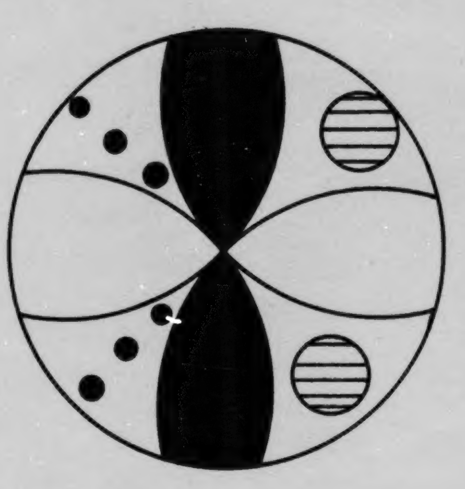


B.

Yes

214

14.



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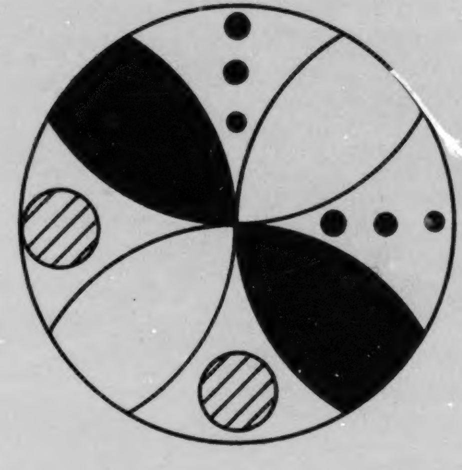

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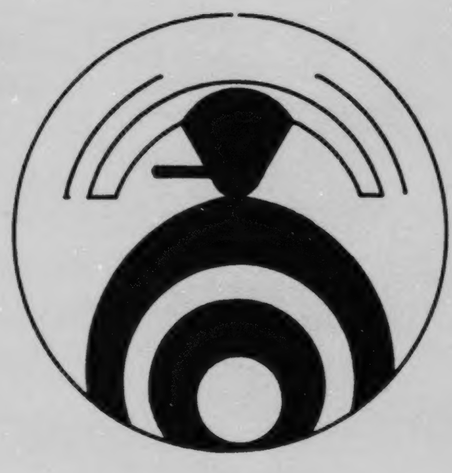

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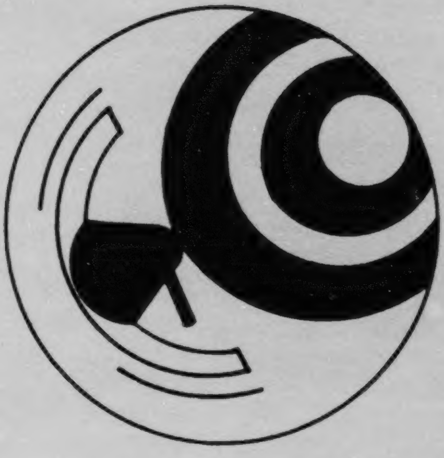


B.

217

Yes

218

SOLUTIONS
ROTATION 2

1 [✓ Yes] No

2 Yes [✓ No]

3 Yes [✓ No]

4 Yes [✓ No]

5 [✓ Yes] No

6 [✓ Yes] No

7 Yes [✓ No]

8 Yes [✓ No]

9 Yes [✓ No]

10 [✓ Yes] No

11 Yes [✓ No]

12 [✓ Yes] No

13 [✓ Yes] No

14 Yes [✓ No]

15 [✓ Yes] No

Spatial Memory & Rotation

SPATIAL MEMORY AND ROTATION

OBJECTIVE

To remember the shape of an object and its relationship to other objects when they are rotated in space.

DIRECTIONS

Glance through the exercises. Each exercise has a box with four objects in it, one in each corner. Study the objects in the box so you can remember what each one looks like and where it is located in relation to the other objects. When you can visualize the box with the objects in it, turn the page and select the box in which the objects have been rotated together. Remember, not only should the box contain the same objects, they should maintain the same positional relationship. Once you have selected the box, mark the answer on the sheet provided.

If you answer all the exercises correctly, go to the set of activities on *Hidden Shapes*. If some of your answers do not agree with the correct answers, you may want to do some of the additional activities suggested in "What Else Can You Do?"

You can also copy each exercise. Cut out the objects within each box and move each so you can match the set with the answer. Note that the objects do not rotate. As you do this, visualize how objects can move within the box while not changing their relationships to the other objects within the box.

APPLICATION

These exercises combine the ability to remember what an object looks like with the ability to mentally rotate that object in space. A simple example might be trying to locate one's car in a large shopping center after exiting from a different door than the door one entered. The assembly of an object often requires remembering and mentally rotating parts in order to complete the final product.

Many occupations require this type of memory and rotation skill. Architects, engineers, plumbers, electricians, and contractors must be able to manipulate and retain images of building components in order to work efficiently. The skill is also required in other careers such as astronomy, chemistry, anthropology, design, drafting, and art.

SPATIAL MEMORY AND ROTATION

WHAT ELSE CAN YOU DO?

Cut out objects from the exercises or draw your own. Attach them together with a string, so that each object itself will not turn. Move the objects together. As you do this visualize the objects moving within the box. Now, remove the string and instead of rotating the set of objects rotate each one individually. Notice the difference in how the objects look from when you moved them with the string attached. You also can rotate the box as was done in *Rotation 1*. There are three types of rotation of the objects you can visualize: the rotation of the objects together in the box; the rotation of each individual object in its corner; and the rotation of the box itself.

Study a photograph. Then try to visualize it from memory. Next try to draw it as if it had been rotated so it was upside-down. Then draw it on its side.

Practice looking at a set of keys. Attempt to determine which key will fit which lock.

Practice visualizing what is behind you.

Create a sculpture using clay. Form a shape you see before you, rotating the shape in your mind as well as with clay. Form a shape you've seen in another room (remember and rotate). Create an imaginary shape.

Study a structure, such as a building, bridge, or fence. Attempt to make a model of it from toothpicks, Play-doh, blocks, or straws. Then mentally rotate the structure and construct the new model.

LIST YOUR OWN IDEAS FOR IMPROVING YOUR SPATIAL MEMORY AND ROTATION SKILLS

ANSWER SHEET
SPATIAL MEMORY AND ROTATION

1 A B C D

2 A B C D

3 A B C D

4 A B C D

5 A B C D

6 A B C D

7 A B C D

8 A B C D

9 A B C D

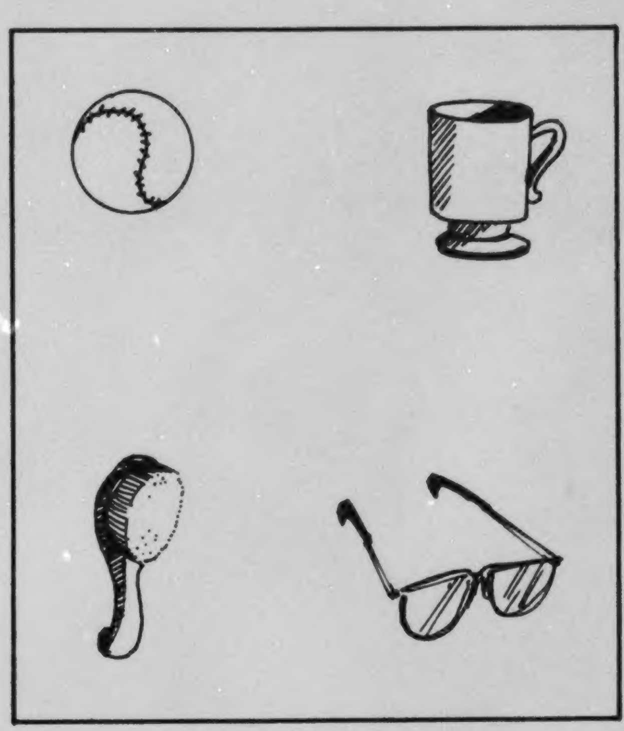
10 A B C D

11 A B C D

12 A B C D

LOOK AT THE OBJECTS IN THE BOX ON THE RIGHT. REMEMBER WHAT EACH ONE LOOKS LIKE AND WHERE IT IS LOCATED IN RELATION TO THE OTHER OBJECTS. THE OBJECTS WILL ALL BE ROTATED WITHIN THE FOUR BOXES ON THE NEXT PAGE. WHEN YOU THINK YOU CAN REMEMBER THE SHAPES AND WHERE THEY'RE LOCATED, TURN THE PAGE AND CIRCLE THE ANSWER FOR THE BOX IN WHICH ALL OF THE OBJECTS HAVE BEEN ROTATED TOGETHER, THAT IS IN WHICH THE OBJECTS REMAIN IN THE SAME ORDER, BUT NOT IN THE SAME POSITION.

THEN, CONTINUE FOR EACH NUMBERED BOX.



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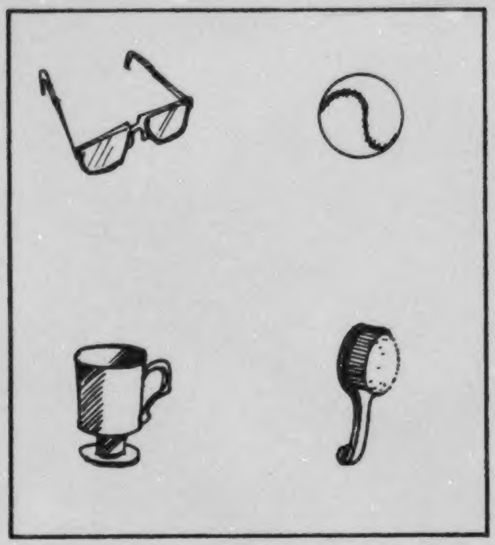

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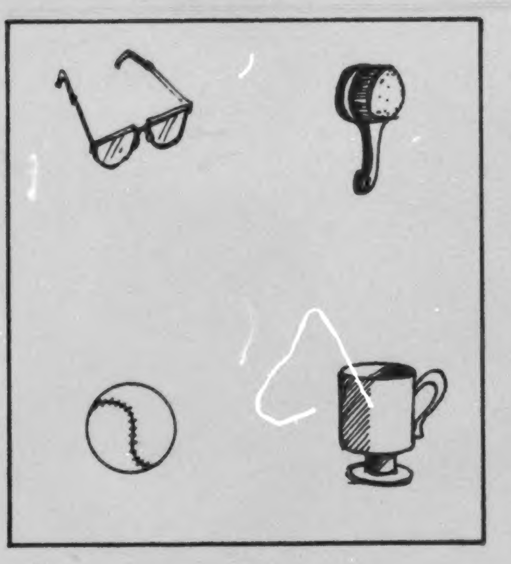

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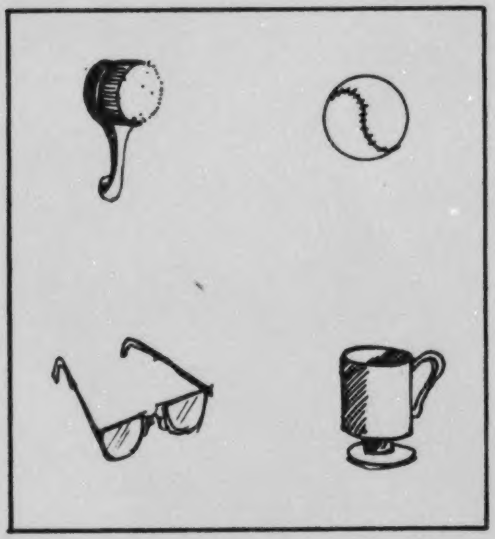

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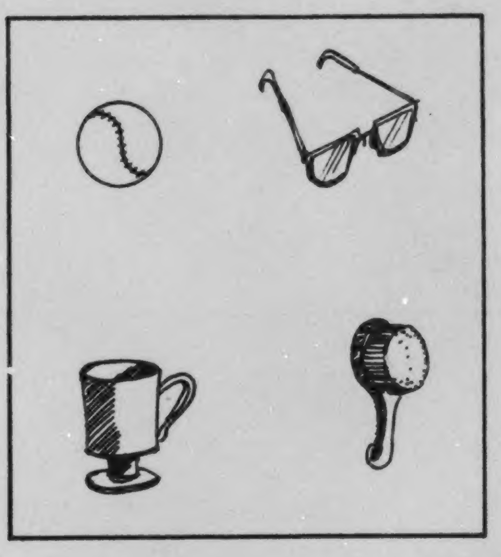
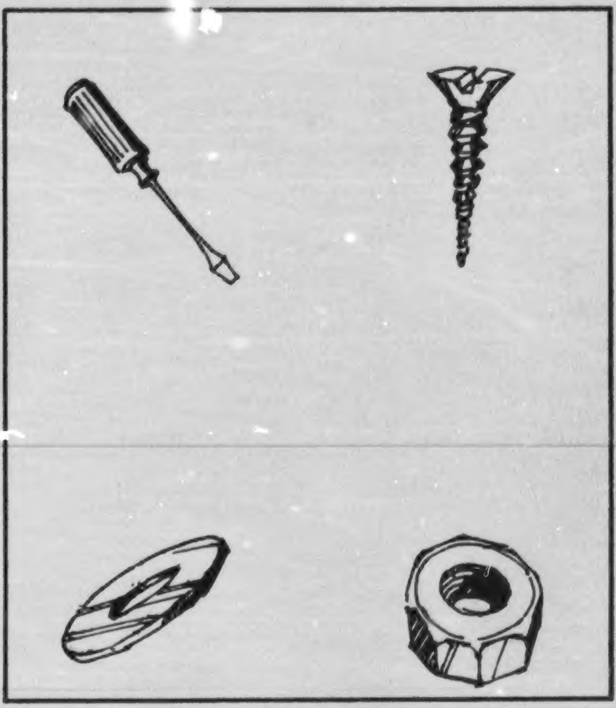


D.

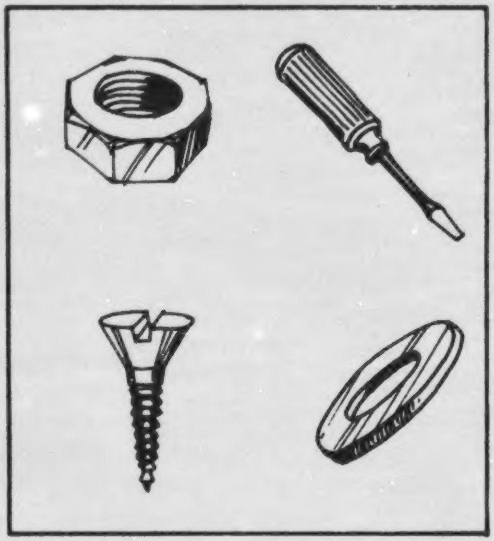
C

LOOK AT THE OBJECTS IN THE BOX ON THE RIGHT. REMEMBER WHAT EACH ONE LOOKS LIKE AND WHERE IT IS LOCATED IN RELATION TO THE OTHER OBJECTS. THE OBJECTS WILL ALL BE ROTATED WITHIN THE FOUR BOXES ON THE NEXT PAGE. WHEN YOU THINK YOU CAN REMEMBER THE SHAPES AND WHERE THEY'RE LOCATED, TURN THE PAGE AND CIRCLE THE ANSWER FOR THE BOX IN WHICH ALL THE OBJECTS HAVE BEEN ROTATED TOGETHER.

NOW, CONTINUE FOR EACH NUMBERED BOX.



2.



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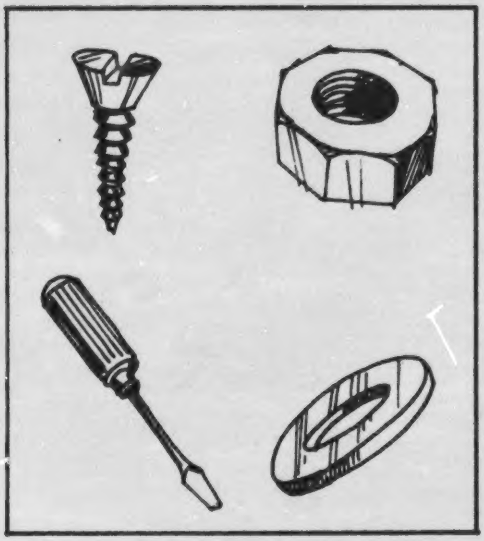

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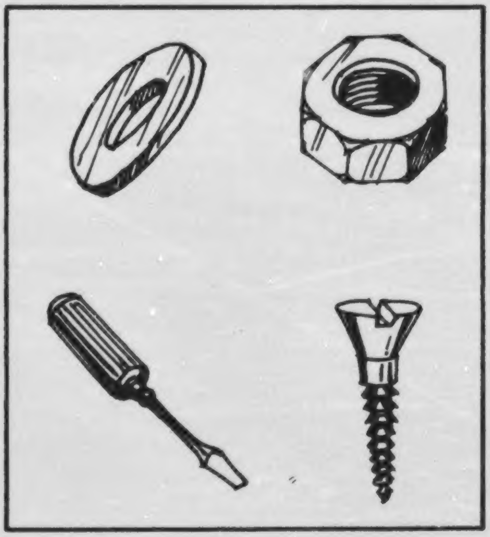

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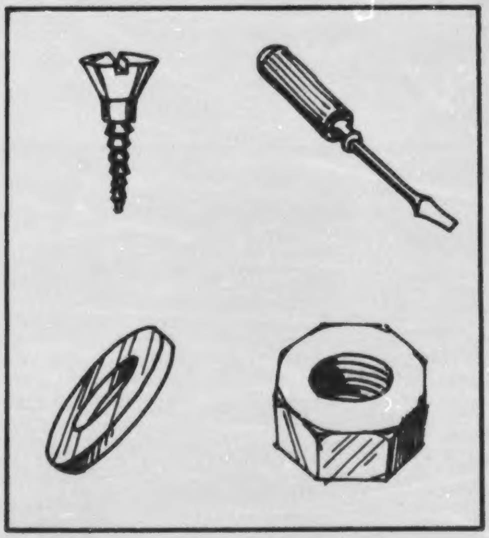
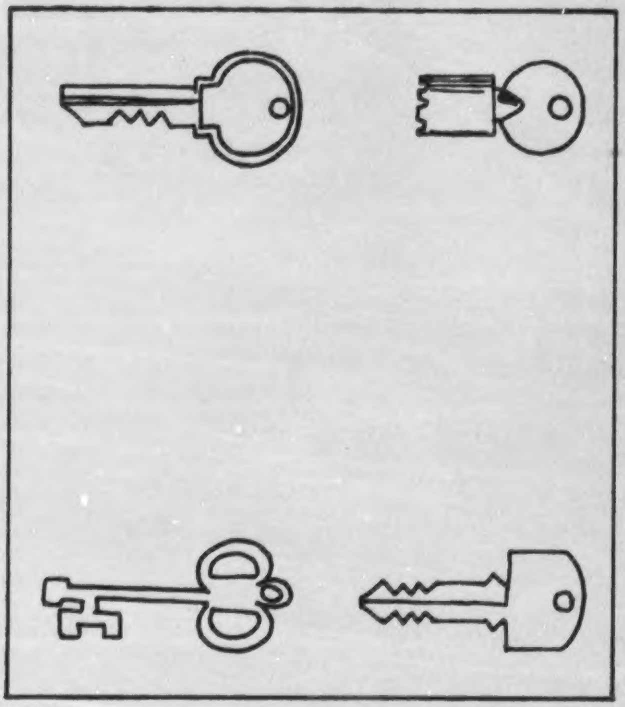


D.

B

231



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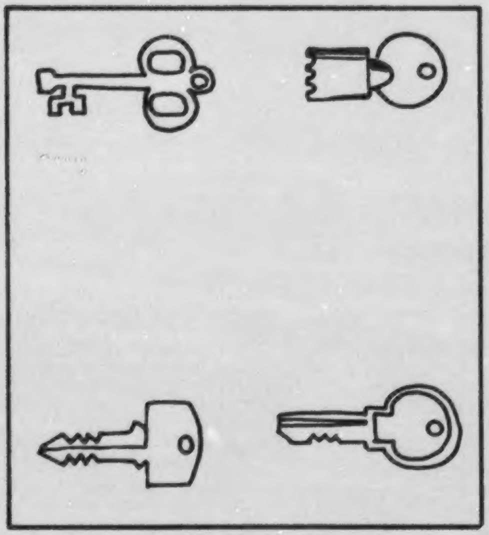

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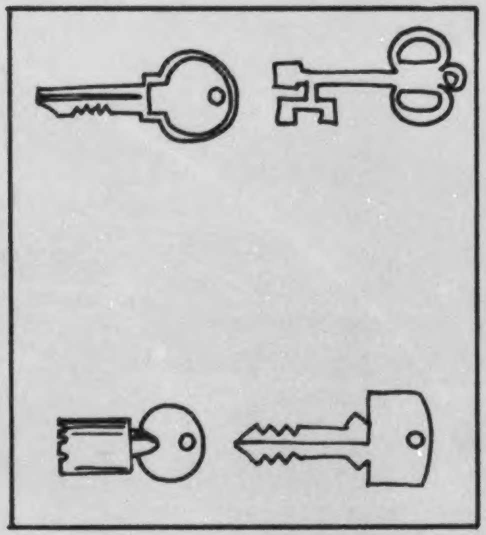

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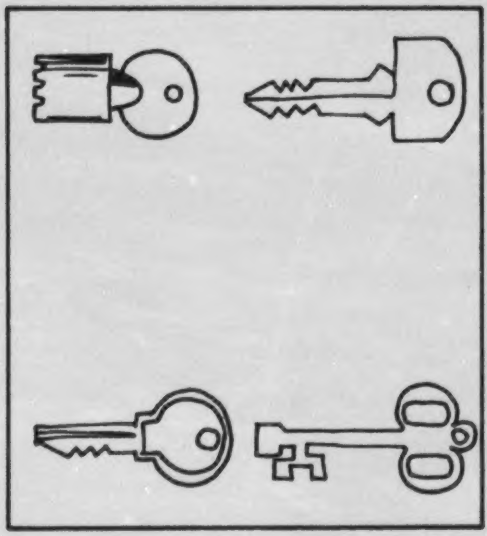

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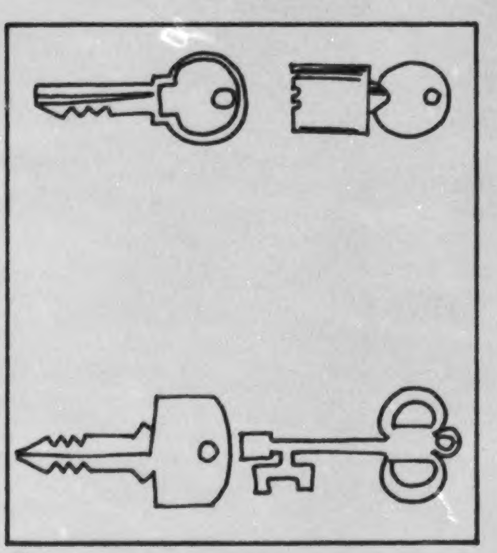

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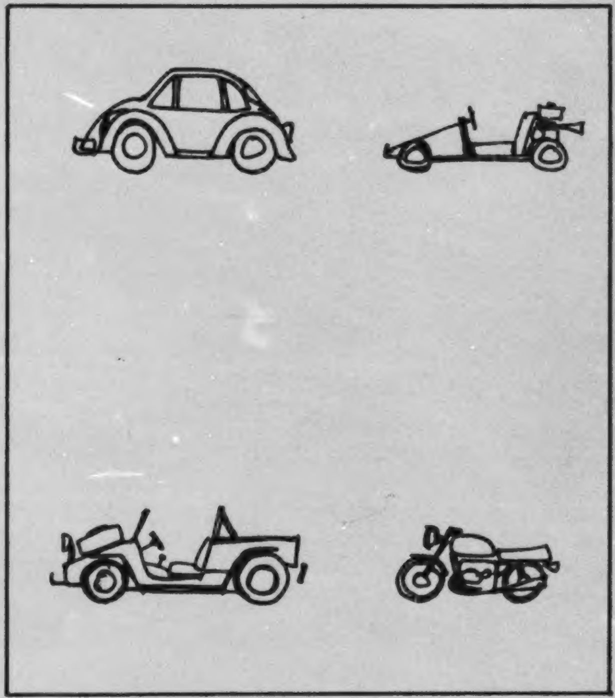

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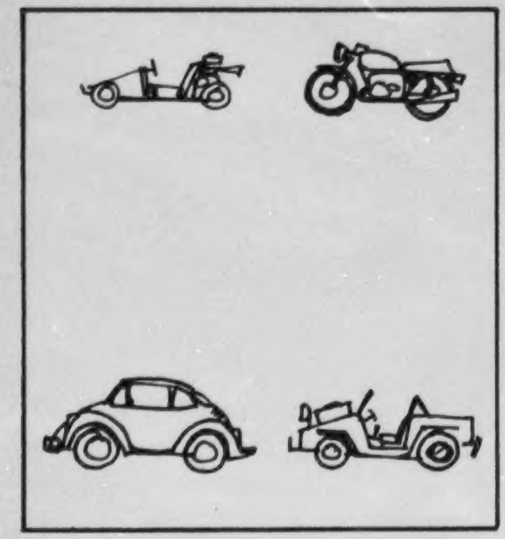

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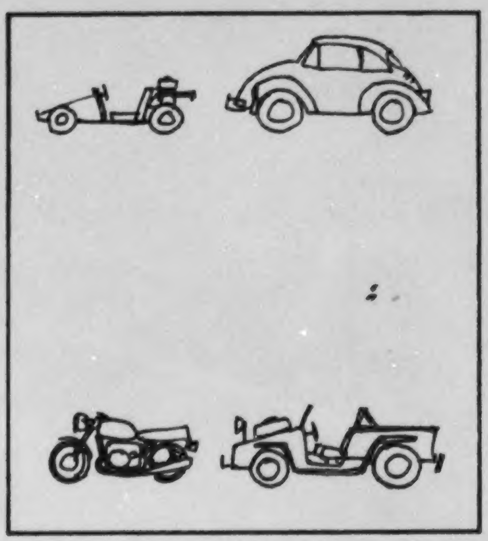

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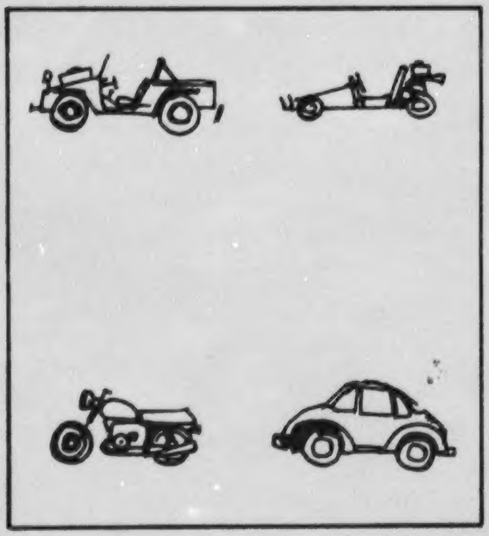

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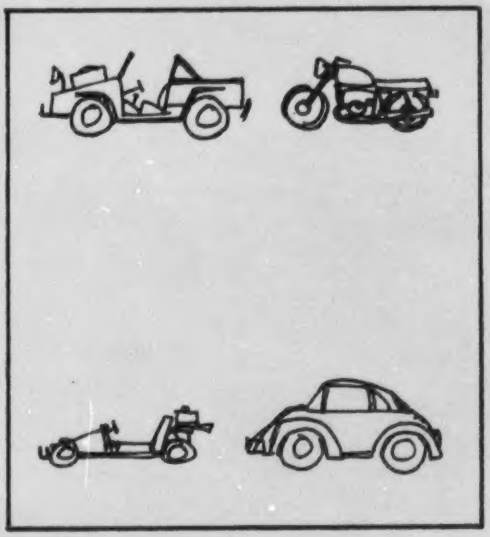

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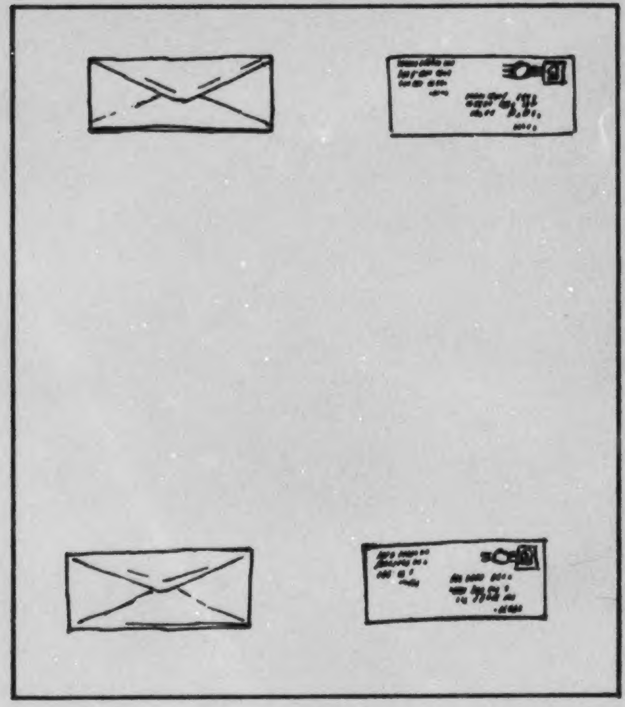

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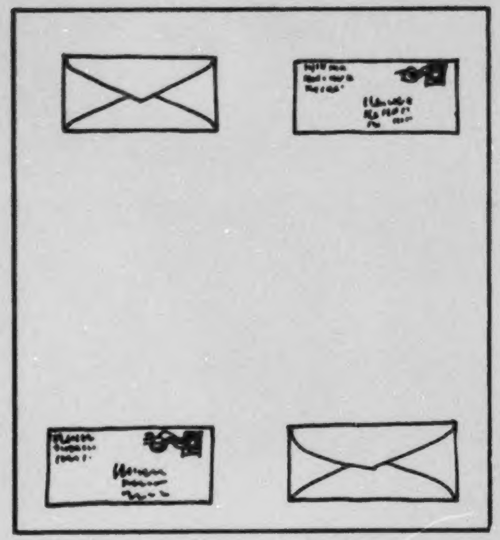

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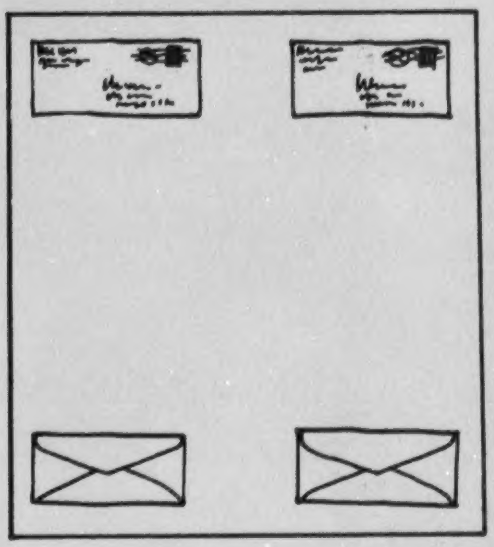

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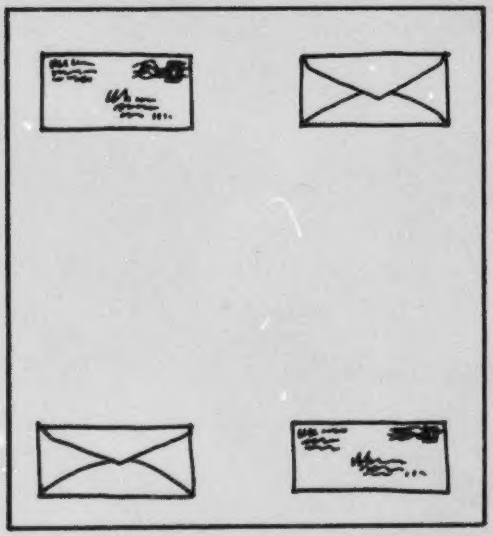

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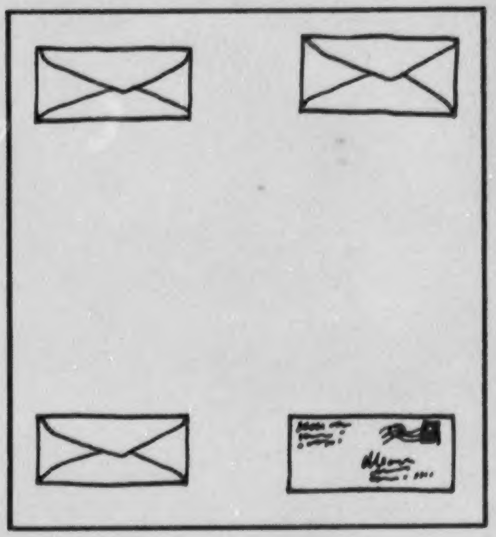
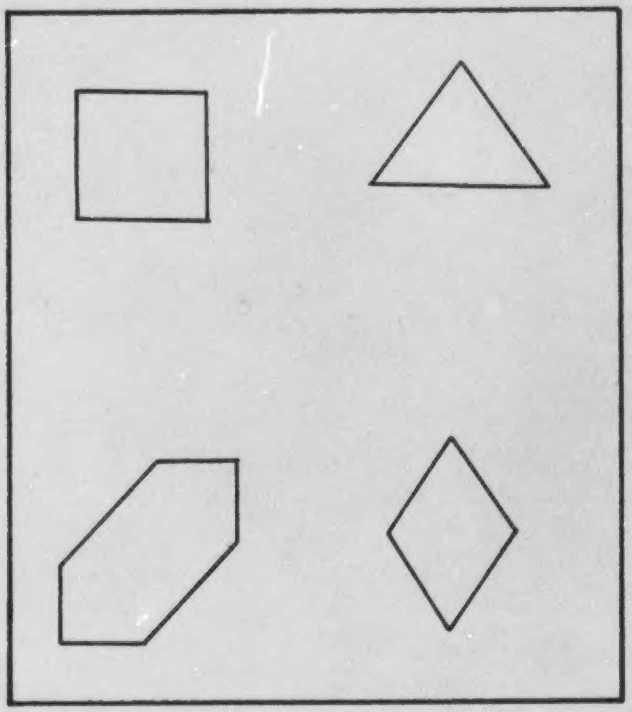


D.

NOW, LET'S TRY SOME GEOMETRIC SHAPES...
IN ADDITION TO THE OBJECTS BEING ROTATED TOGETHER, IN SOME OF THE BOXES THE OBJECTS THEMSELVES MAY ROTATE OR CHANGE ANGLES.



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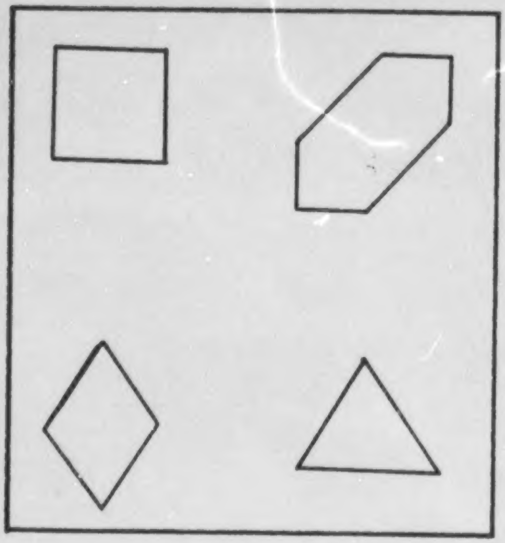

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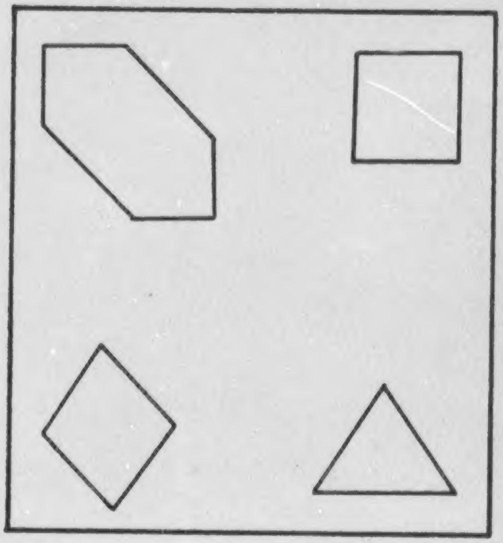

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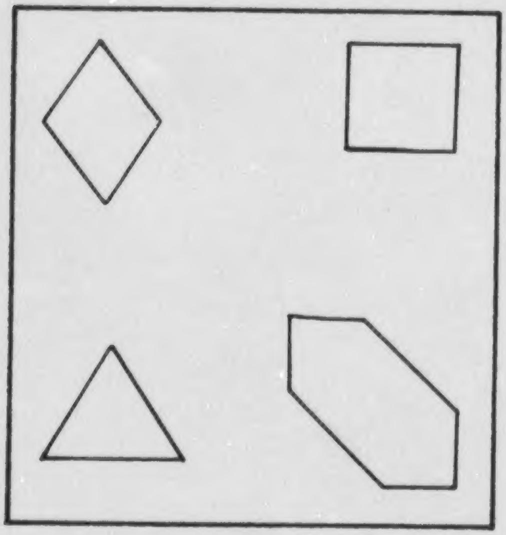

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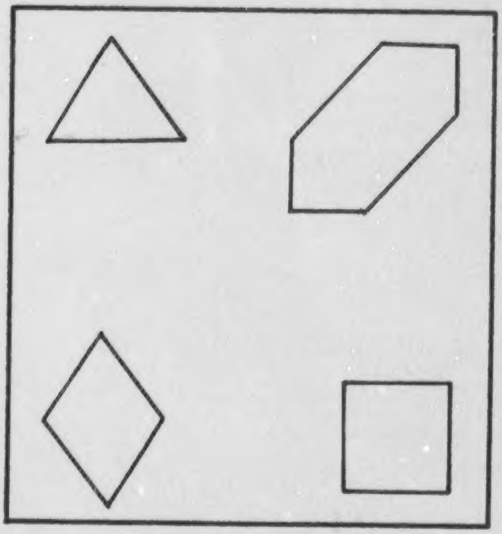

D.

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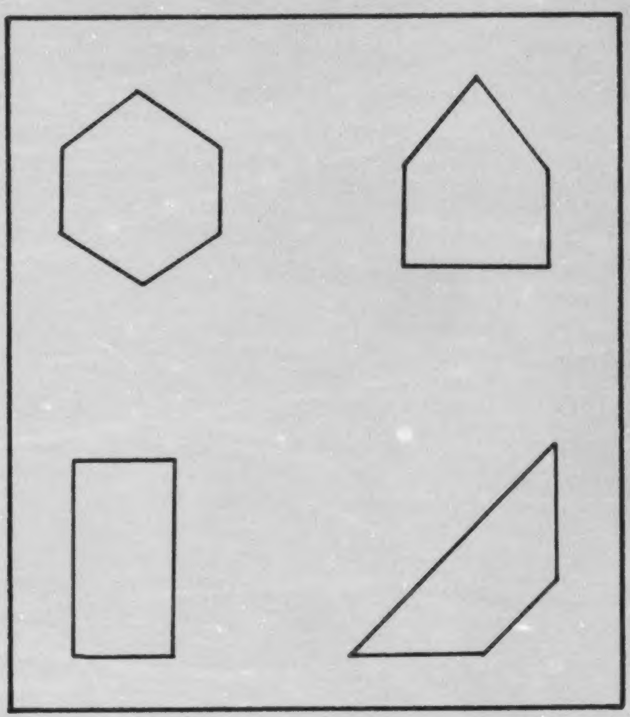

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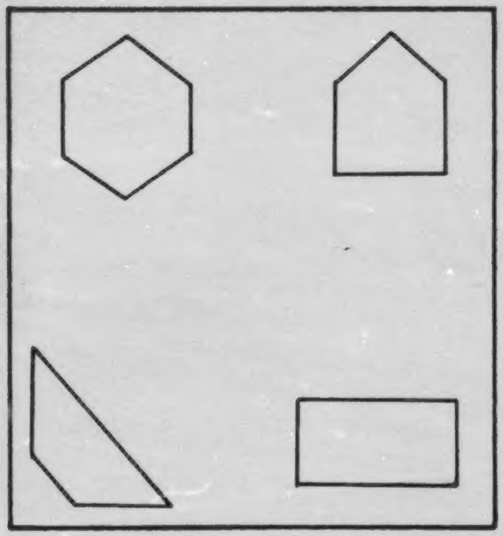

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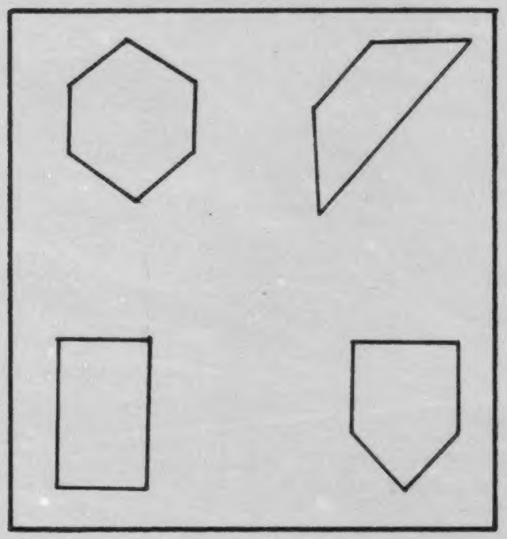

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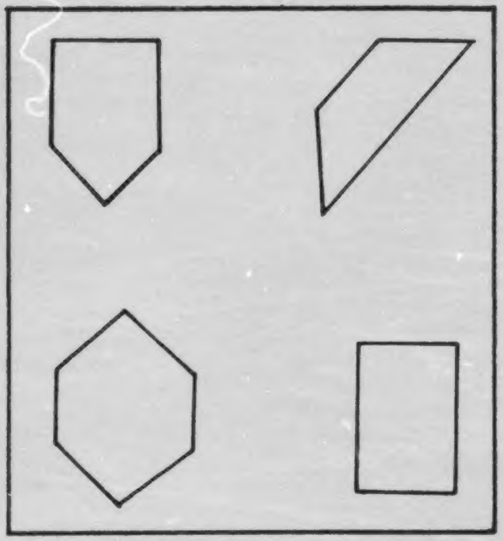

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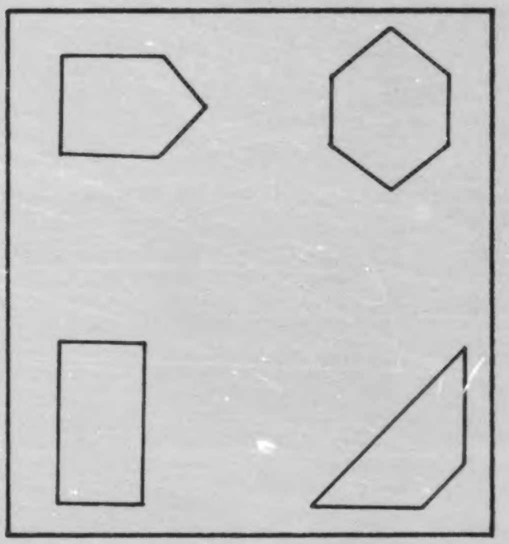

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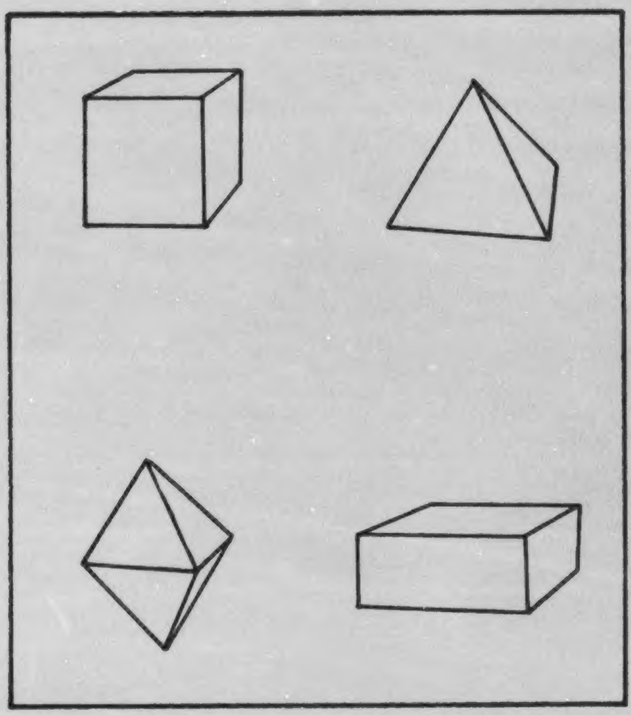

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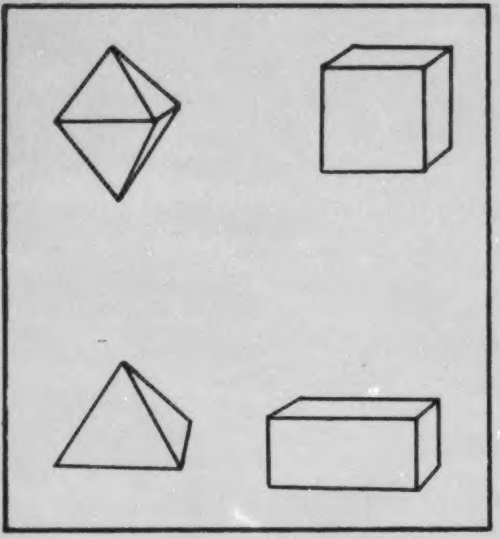

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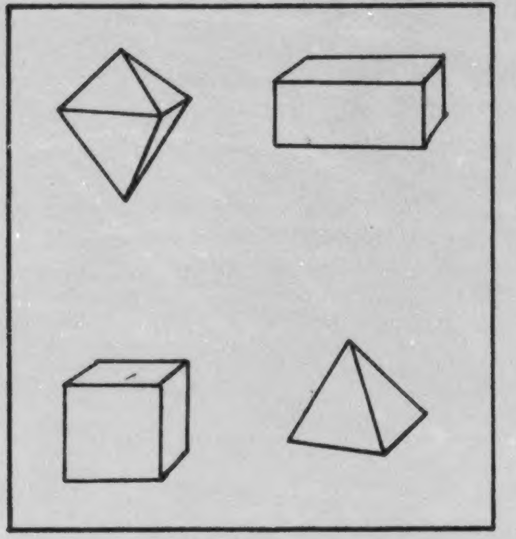

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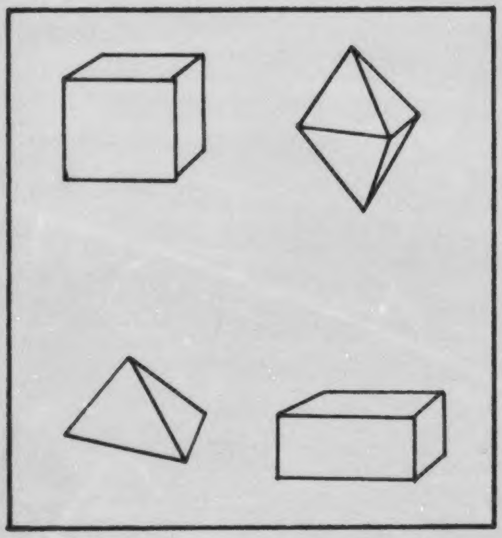

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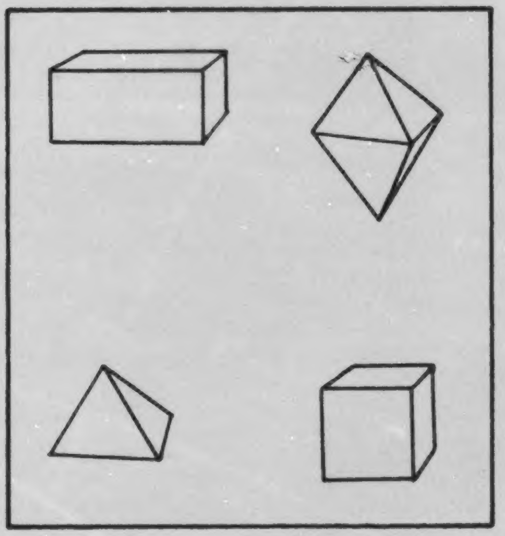

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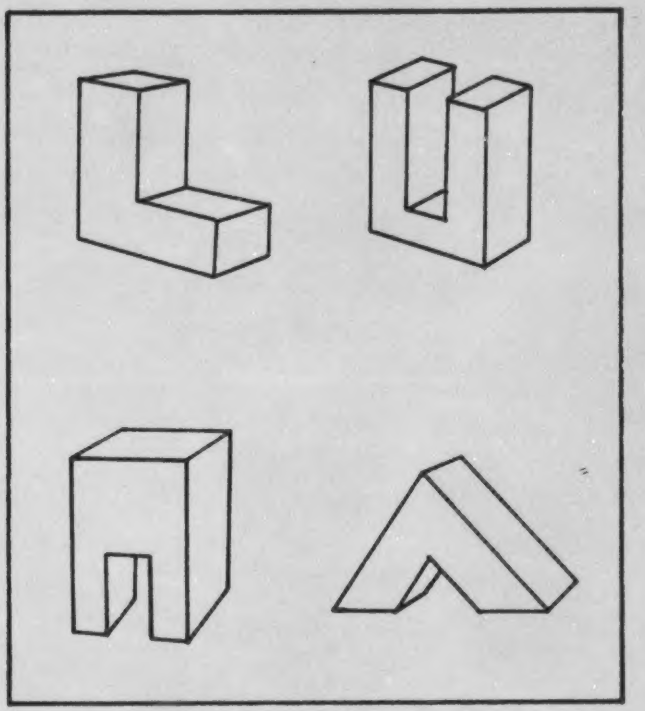
8. D



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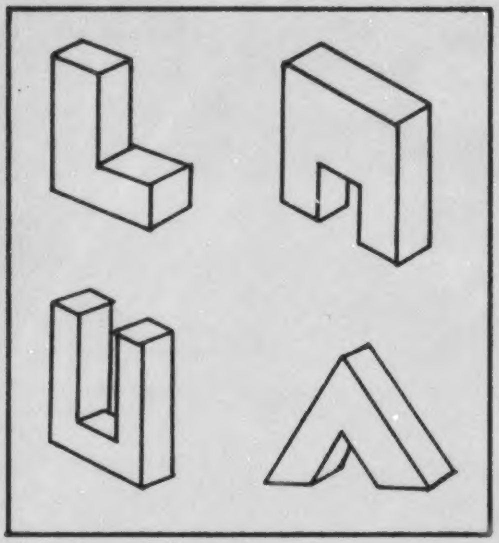

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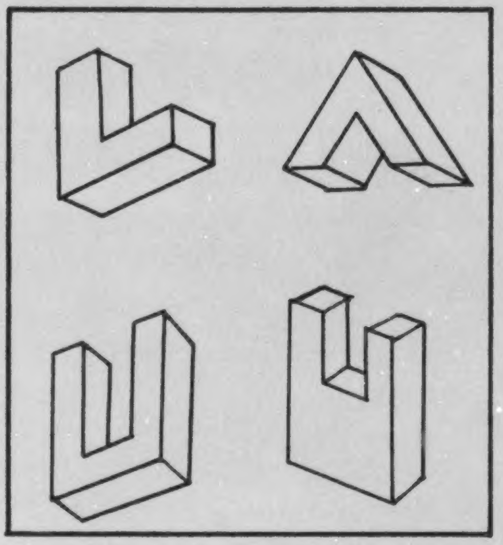

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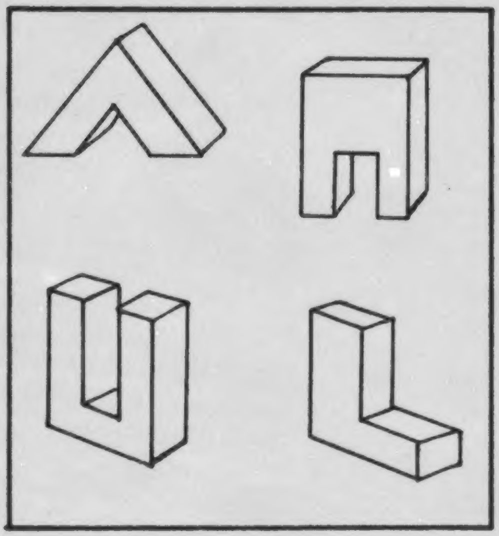

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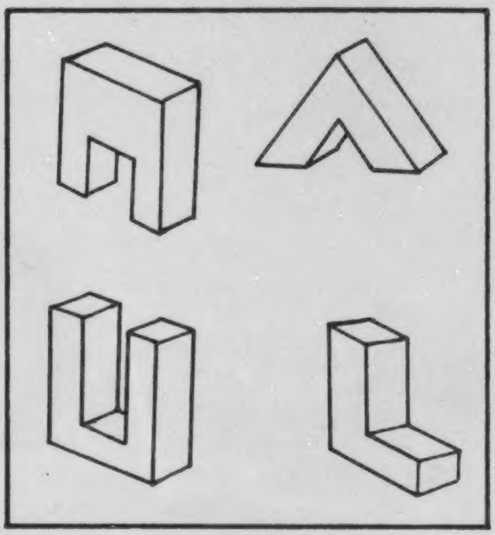

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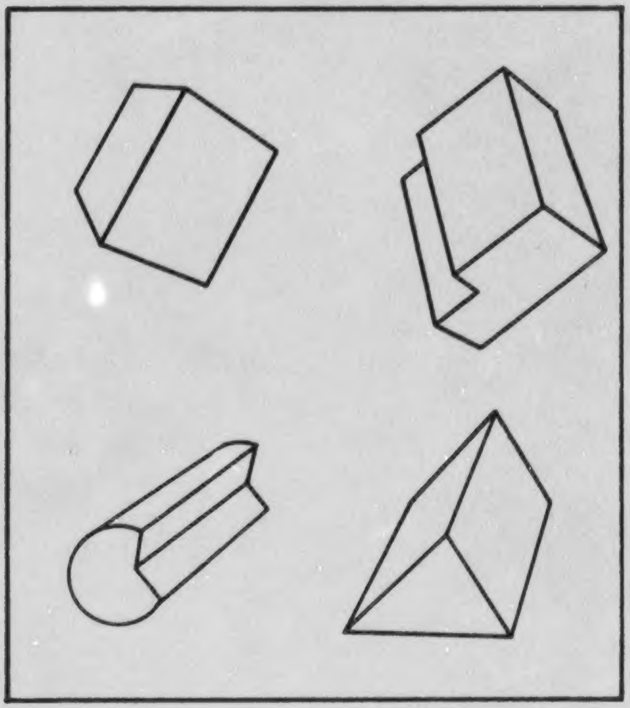

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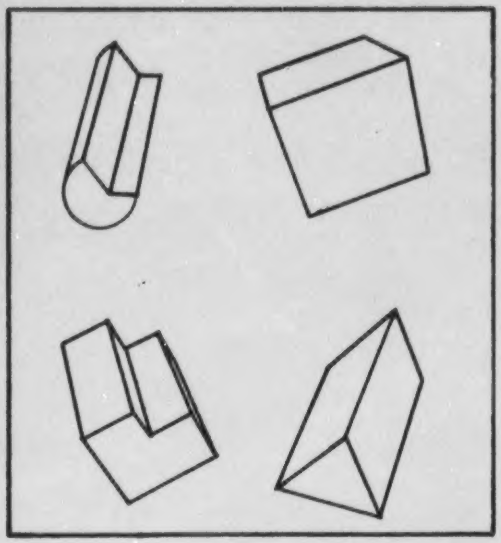

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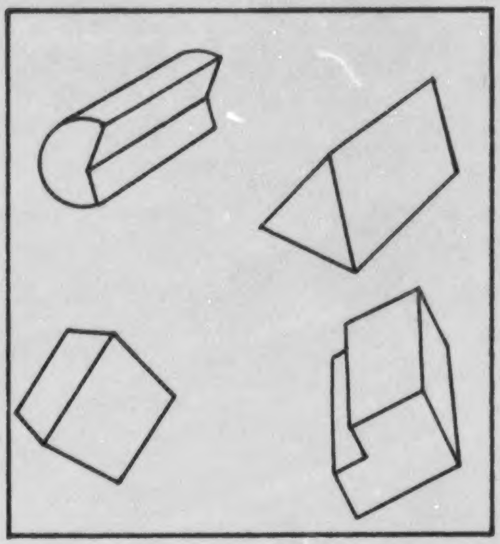

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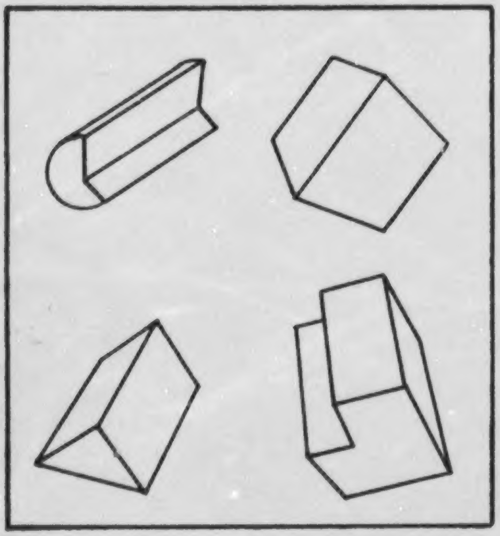

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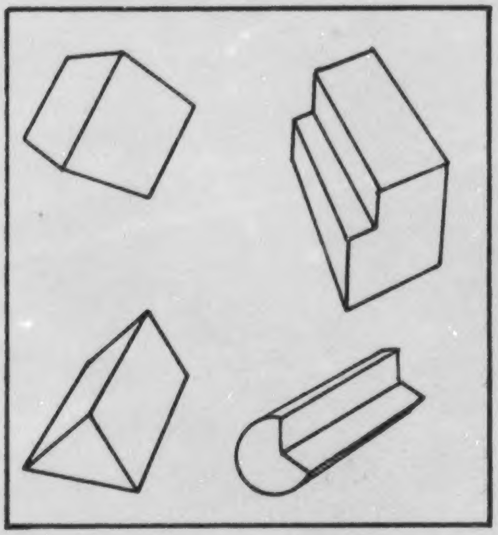

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C

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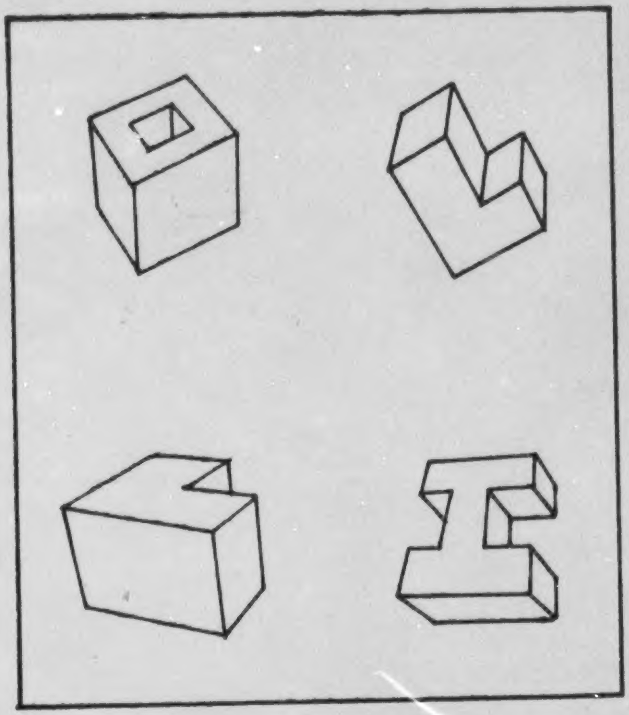

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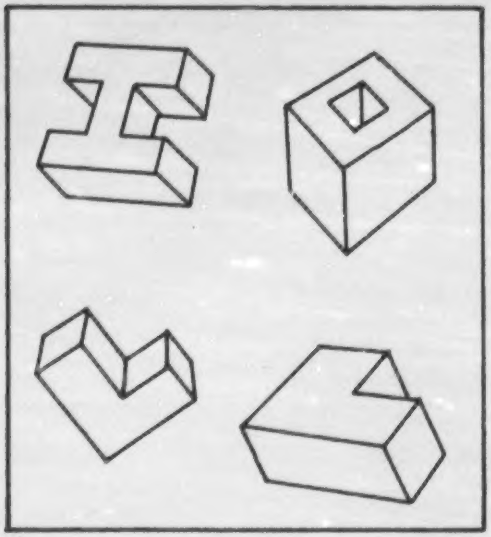

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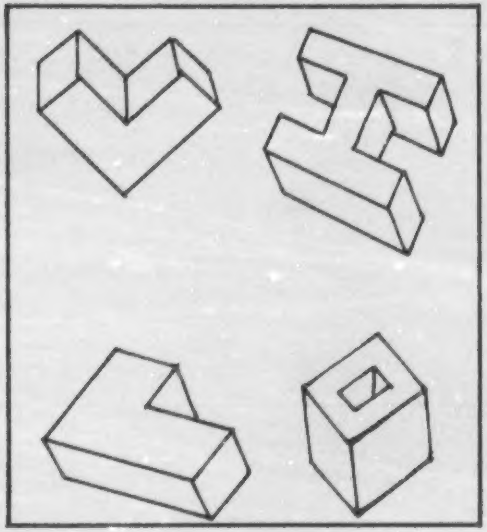

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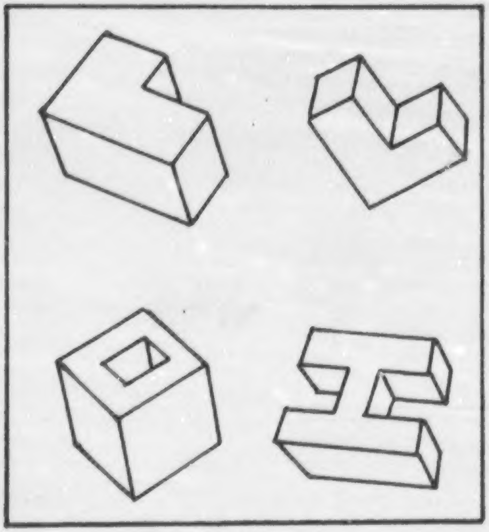

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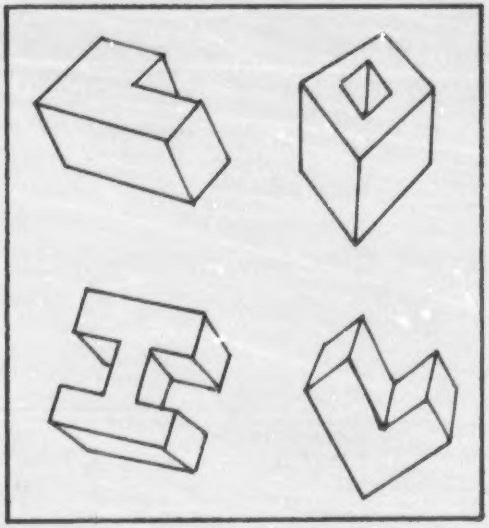
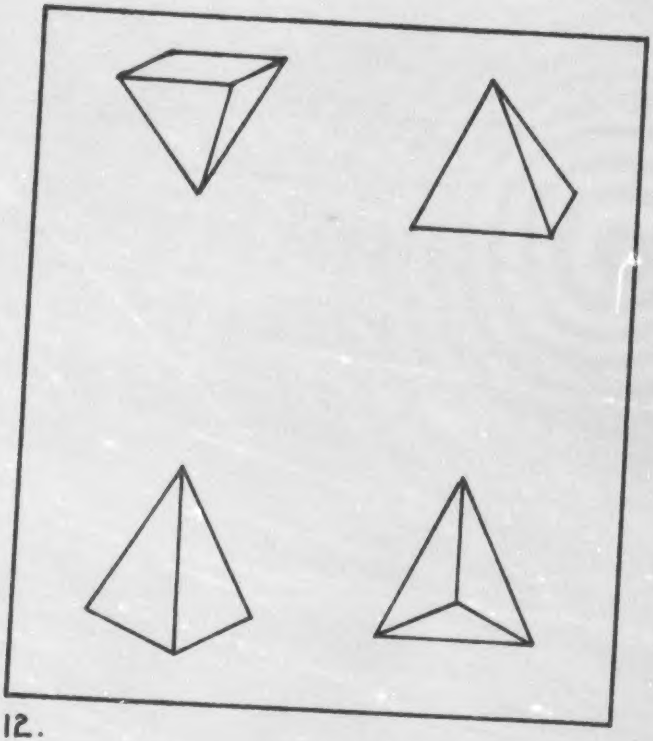


D.

1. D

253



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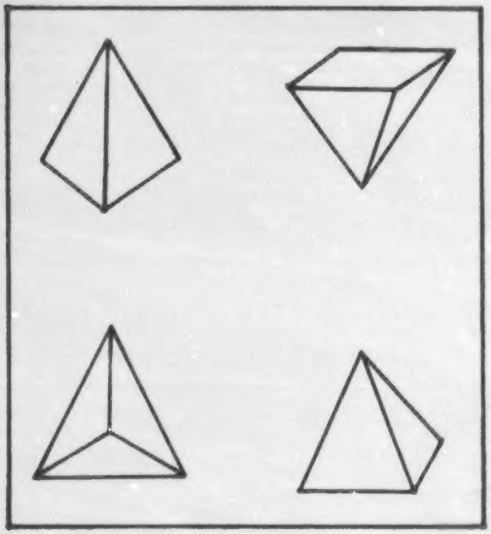

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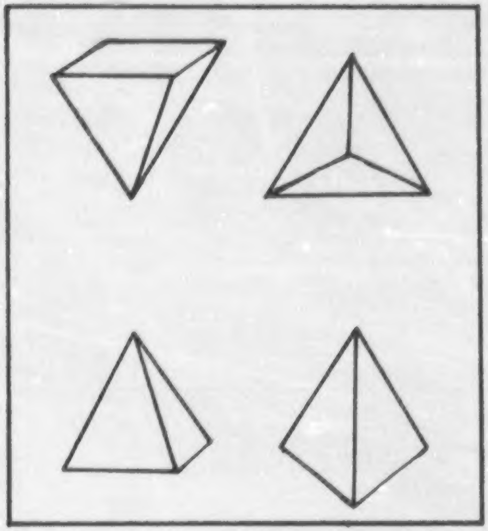

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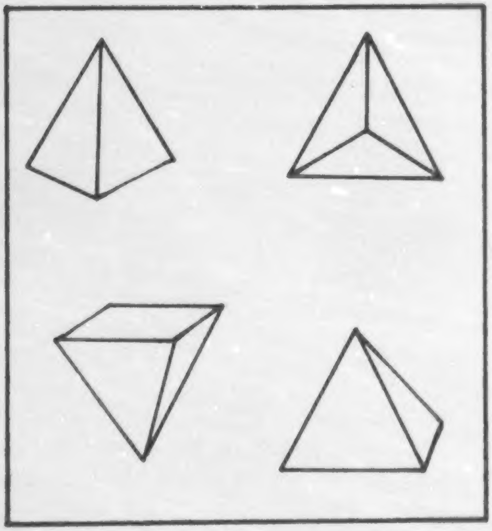

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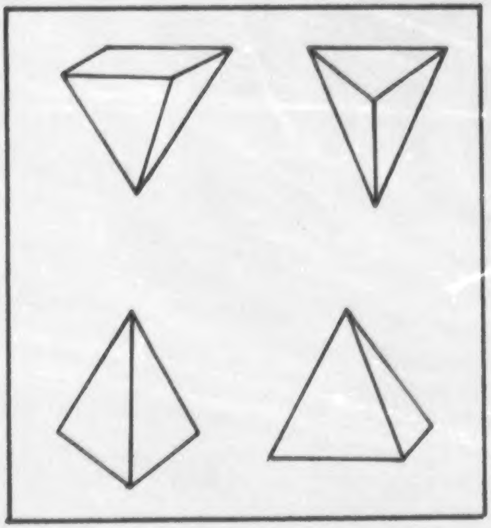

D.

12. A

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SOLUTIONS
SPATIAL MEMORY AND ROTATION

1 A B [✓ C] D

2 A [✓ B] C D

3 A B [✓ C] D

4 [✓ A] B C D

5 A [✓ B] C D

6 A [✓ B] C D

7 A B [✓ C] D

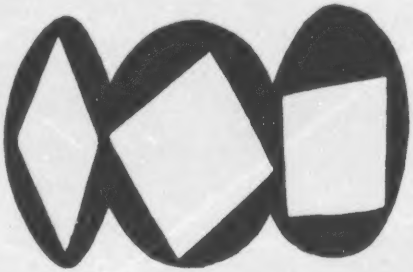
8 A B C [✓ D]

9 A B [✓ C] D

10 A B [✓ C] D

11 A B C [✓ D]

12 [✓ A] B C D



Hidden Shapes

SPATIAL ENCOUNTERS

HIDDEN SHAPES

OBJECTIVE

To focus on an object or shape while ignoring irrelevant background information.

DIRECTIONS

Look through the exercises. Notice that a shape is given in the lower left-hand corner of each page. That shape will be located inside one of the boxes on the page. The size and position of the shape may not be the same as the drawing in the corner. The shape may be turned on its side or rotated a half-turn; it may also be larger or smaller than the drawing. You want to locate the shape inside the box and then mark that box as your answer on the answer sheet provided. In exercises 1 through 14, the shapes will be relatively clear or easy to locate. In exercises 15 through 23, the shapes will be hidden in the pattern and will be more difficult to find. The irrelevant information increases in these drawings, making the shape more difficult to locate.

If you answer all the exercises correctly, go on to the final set on *Cutout Forms*. But, if some of your answers are not correct, you may want to copy the shapes, cut them out, and try to locate them in the boxes by turning each shape and trying to match it to its corresponding shape in the box.

Additional activities are given under "What Else Can You Do?" on the next page.

APPLICATION

These exercises can help one develop the ability to pick out an object or distinguish a shape when it appears as part of other objects or shapes. A person who wears contact lenses is often faced with the task of trying to locate a lense on a rug or floor. Other objects which might be dropped on the floor present the same challenge. The skill is the ability to focus on the object without being distracted by the background.

This focus skill is required in a broad range of careers. For example, in aviation, a pilot must locate landmarks against a landscape or city background; in art and design, the artist must focus on a part rather than the whole; and in X-ray technology, the technician must locate and interpret a shape or pattern against the broader background. Other careers that use this skill include architecture, biochemistry, biology, engineering, geography, and laboratory technology.

HIDDEN SHAPES

WHAT ELSE CAN YOU DO?

Take two photographs of the same object so that in one photograph the depth of field includes a clear view of all objects and in the other only the foreground objects are in focus and the background objects are blurred. Compare the two photographs.

Practice by focusing your eyes on a whole scene outdoors, then by focusing on selected parts of the scene. Then pick one object and try to see it in detail at the same time you are observing the entire scene.

Do simple weaving to create patterns of colors and shapes.

Draw your own hidden picture and have someone attempt to focus on it.

Work mazes. Try to see the maze without tracing the pattern.

Look at intricate patterns in a geometric painting. Try to pick out the different shapes.

Obtain an introductory psychology textbook that has a section on embedded figures. Look at the examples and try to see the various figures.

Study systems. Looks at parts in relation to the whole -- engines, radio, vacuum cleaners, sewing machines, etc.

LIST YOUR OWN IDEAS TO IMPROVE YOUR ABILITY TO LOCATE HIDDEN SHAPES

ANSWER SHEET
HIDDEN SHAPES

1 A B C

2 A B C

3 A B C

4 A B C

5 A B C

6 A B C

7 A B C

8 A B C

9 A B C

10 A B C

11 A B C

12 A B C

13 A B C

14 A B C

15 A B C

16 A B C

17 A B C

18 A B C

19 A B C

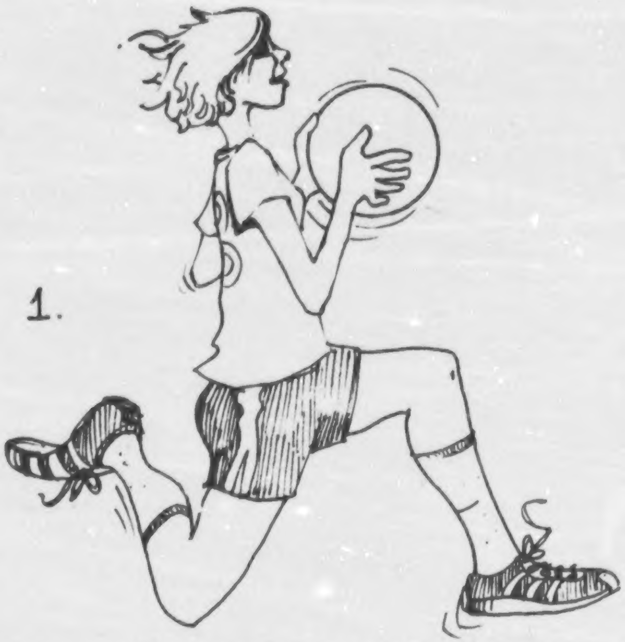
20 A B C

21 A B C

22 A B C

23 A B C

1.



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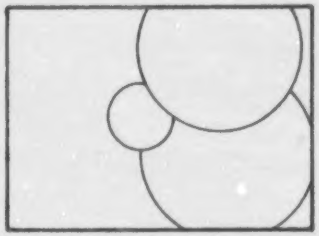

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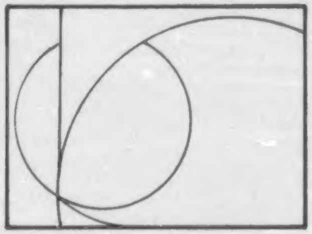

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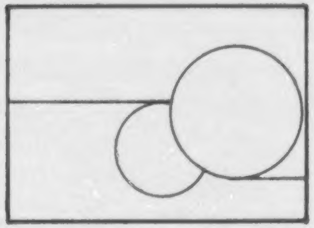
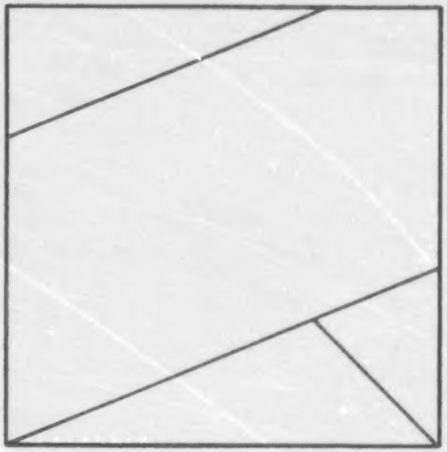
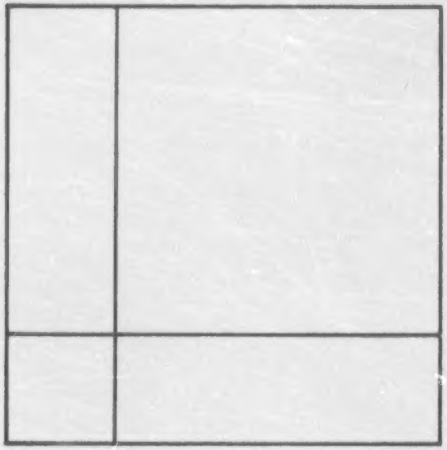


LOOK AT THE SHAPES INSIDE THE BOXES ON THE RIGHT. NOTICE THE SHAPE THE STUDENT ON THE LEFT IS HOLDING. THAT SHAPE IS THE SAME AS A SHAPE INSIDE ONE OF THE BOXES. WHICH BOX CONTAINS THE SAME SHAPE? CIRCLE THE CORRECT ANSWER. NOW, CONTINUE TO DO THE SAME FOR EACH SHAPE GIVEN.

1. C

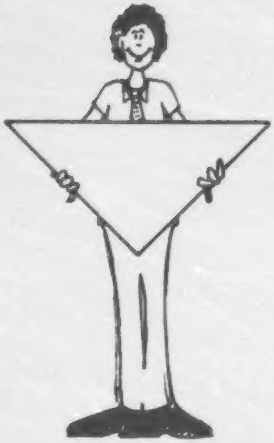


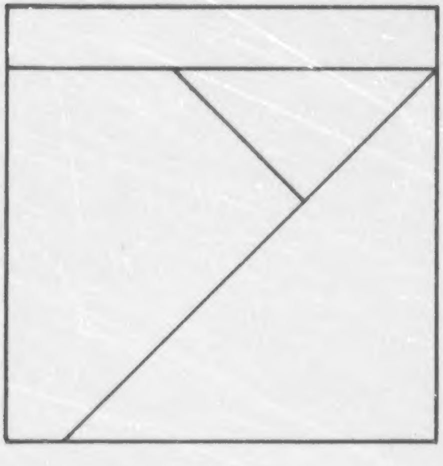
A.



B.

2.

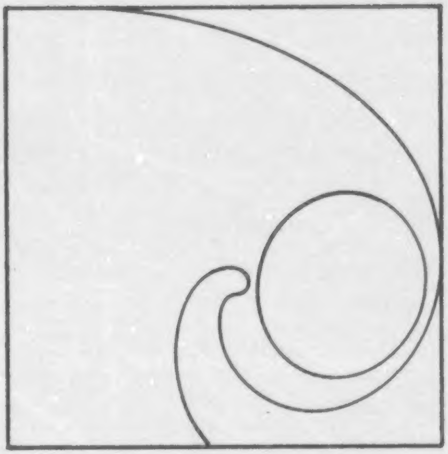




C.

THE SIZE AND POSITION OF THE SHAPE MAY NOT BE THE SAME AS THE EXAMPLE. THE SHAPE MAY BE TURNED ON ITS SIDE, OR IT MAY BE LARGER OR SMALLER.

C



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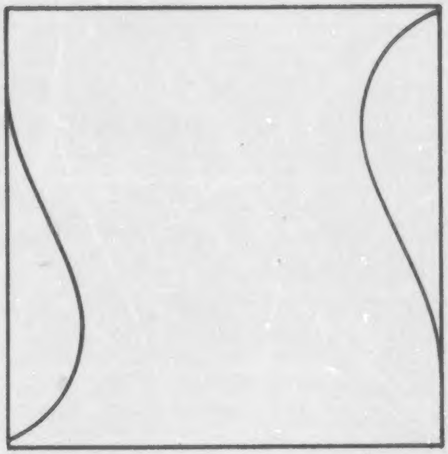

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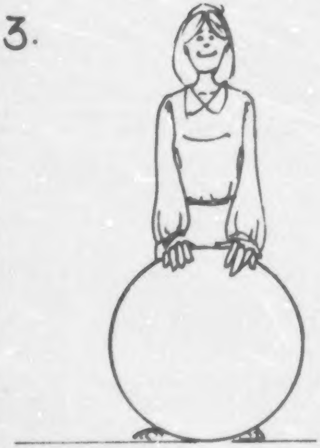
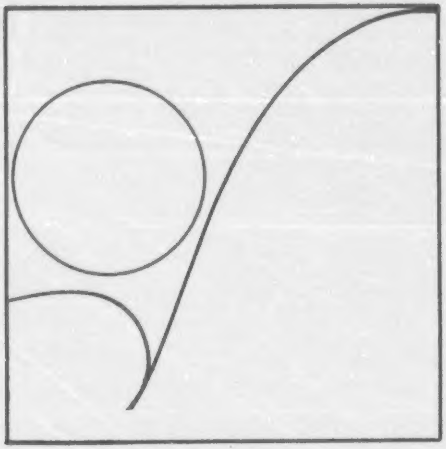
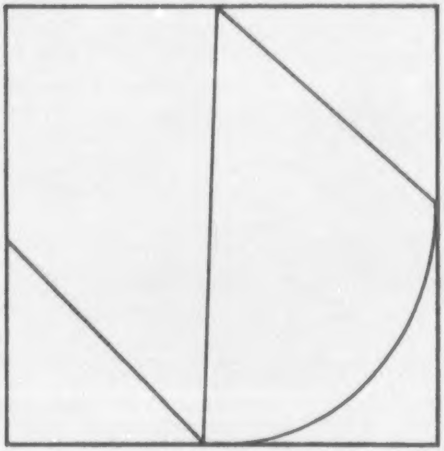
3.





C.

C



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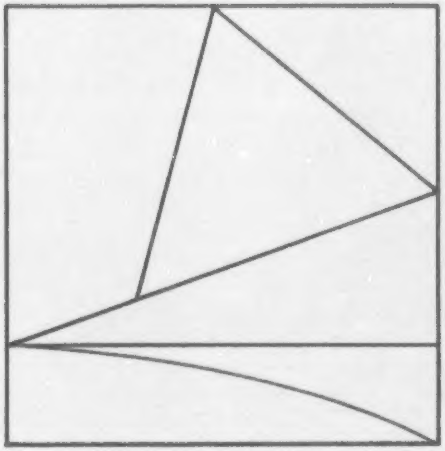

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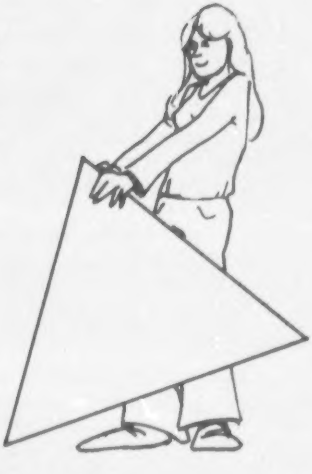

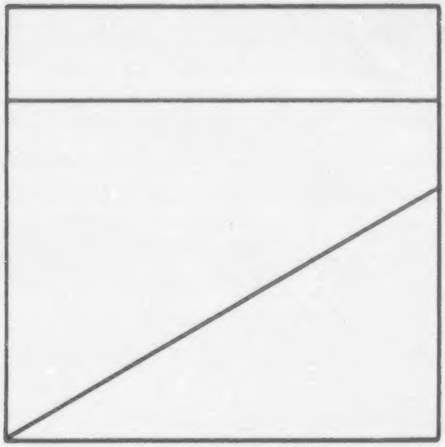

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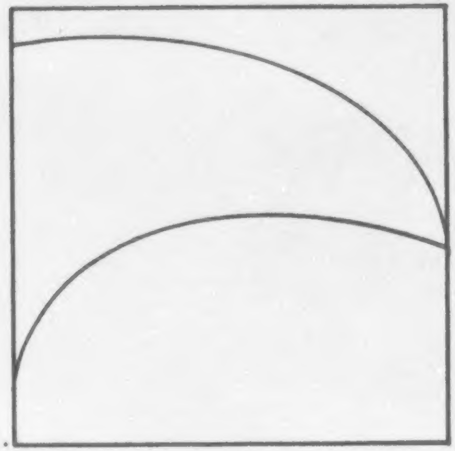

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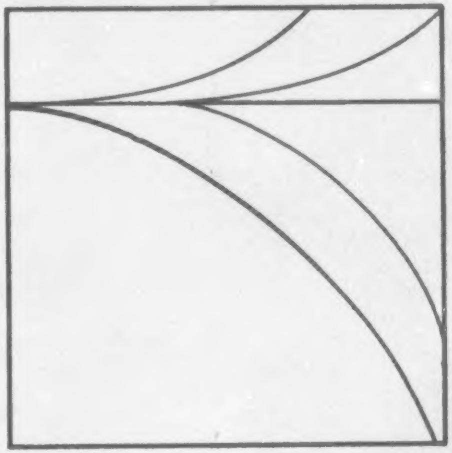

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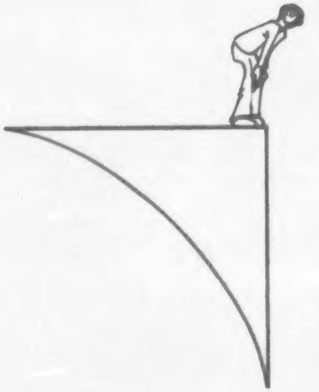

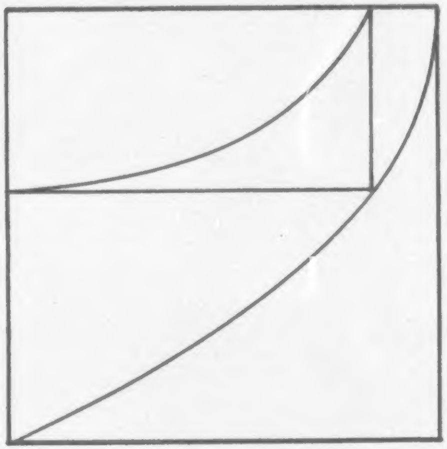

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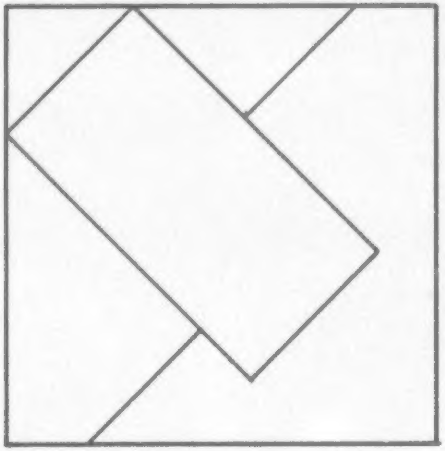

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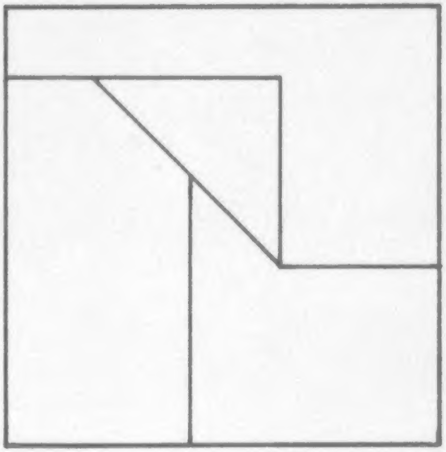

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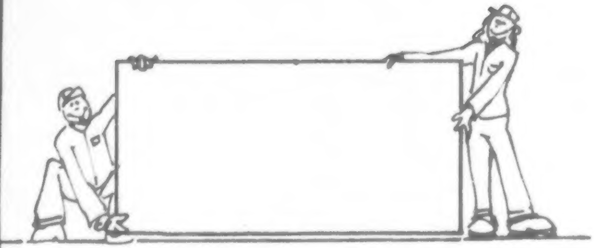

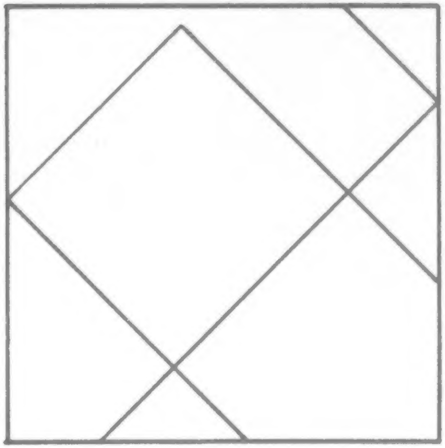

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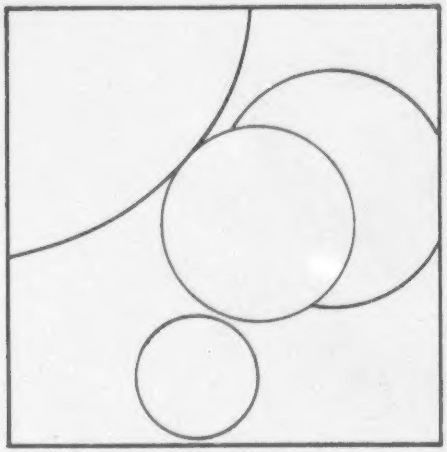

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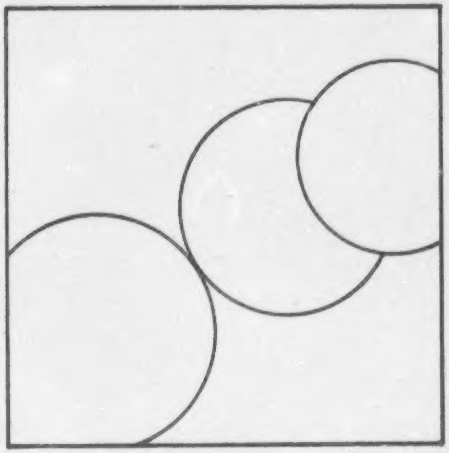

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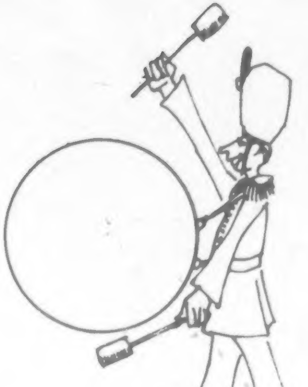

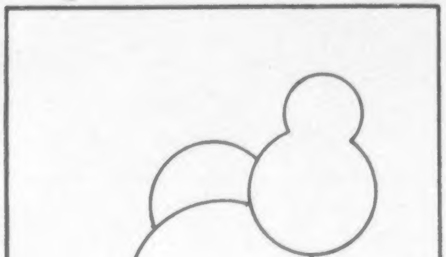

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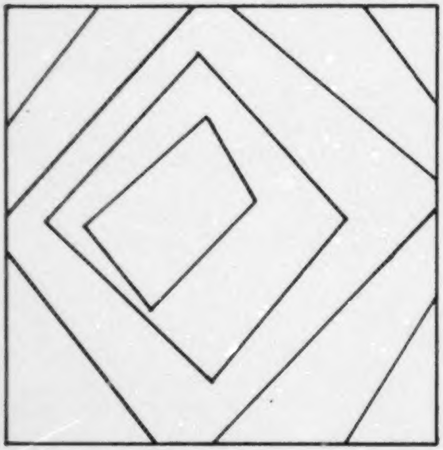

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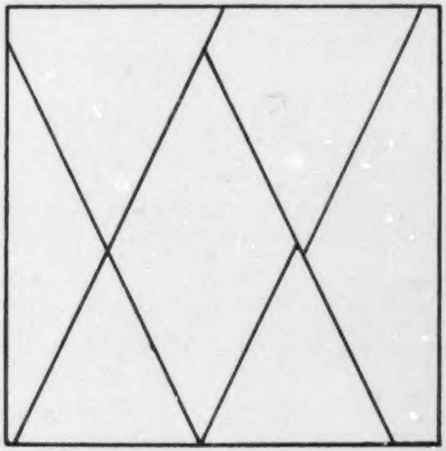

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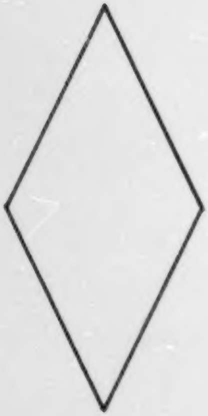

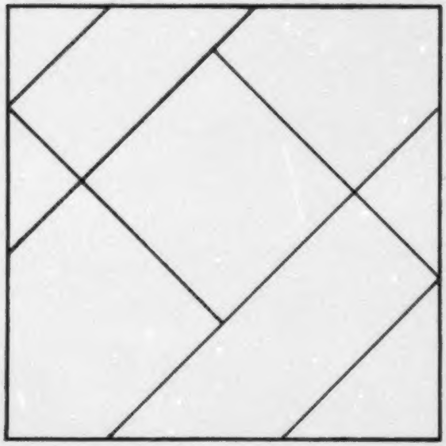

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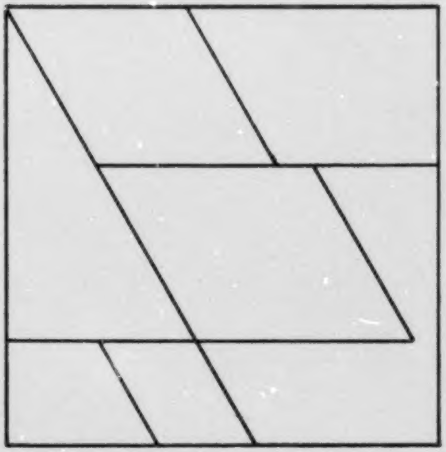

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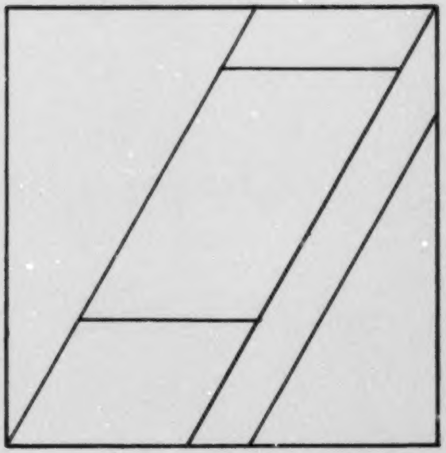

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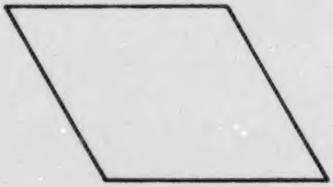

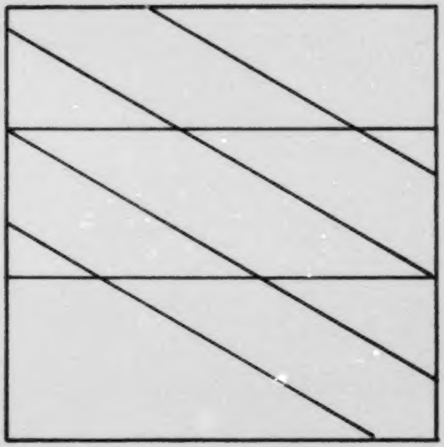

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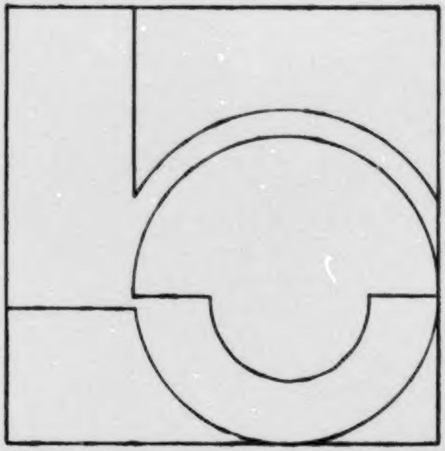
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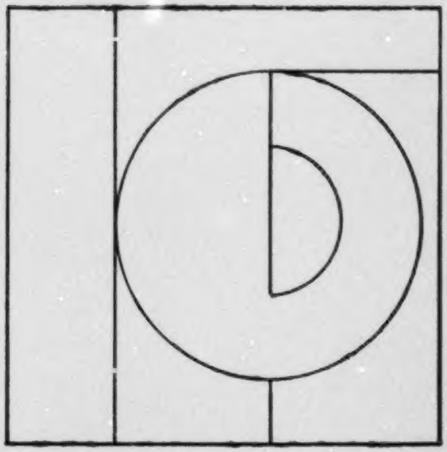
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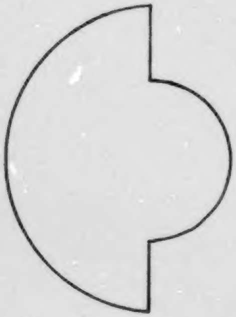

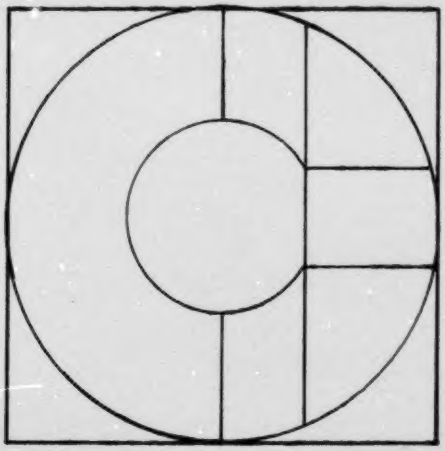
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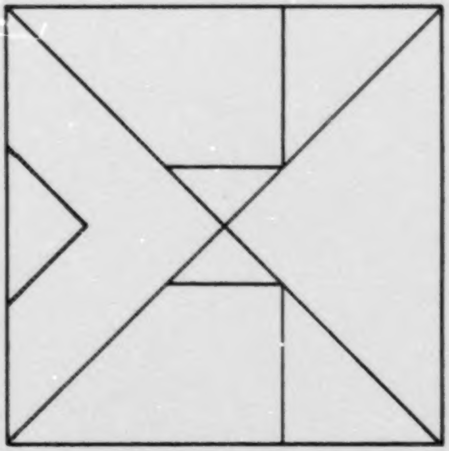

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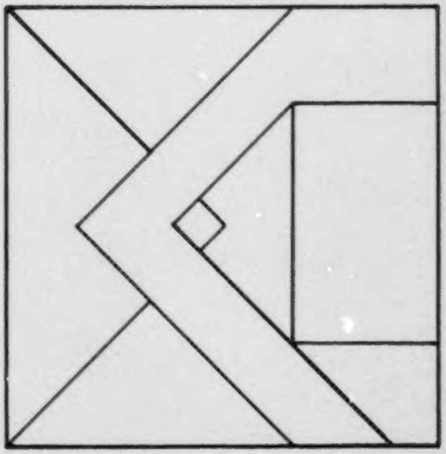

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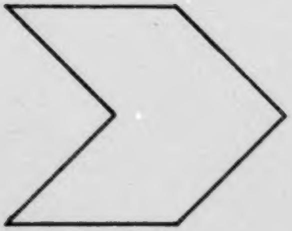

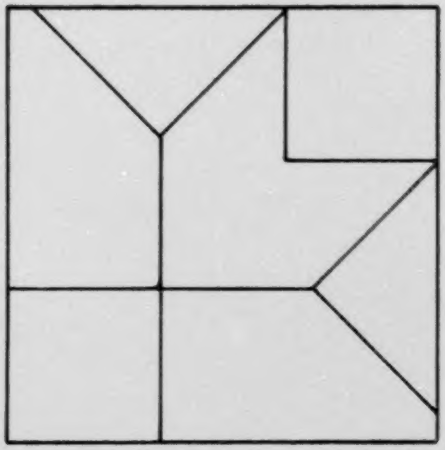

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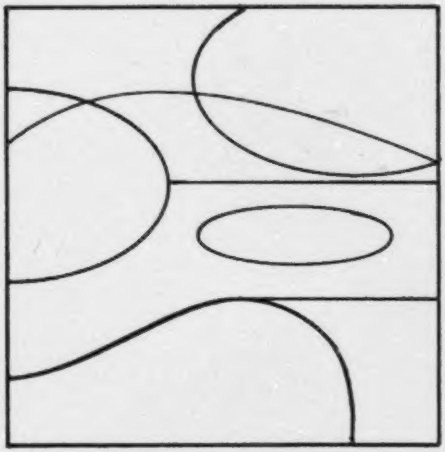

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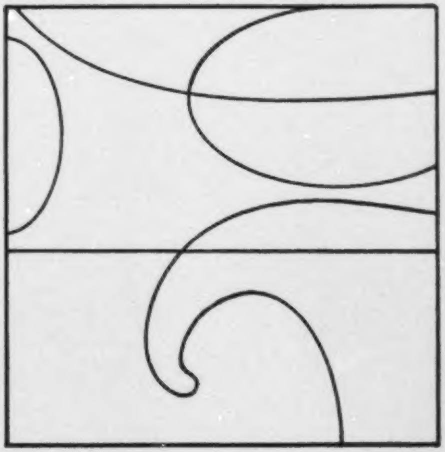

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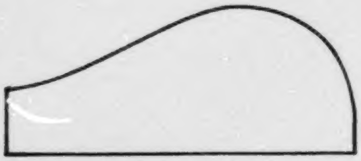

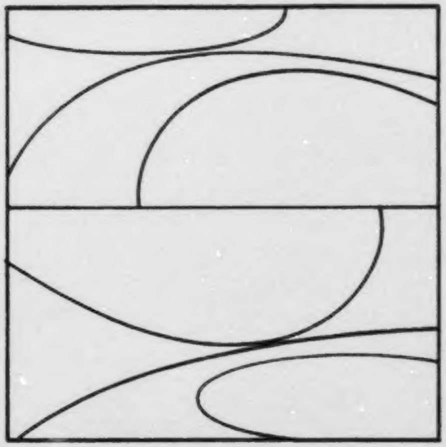

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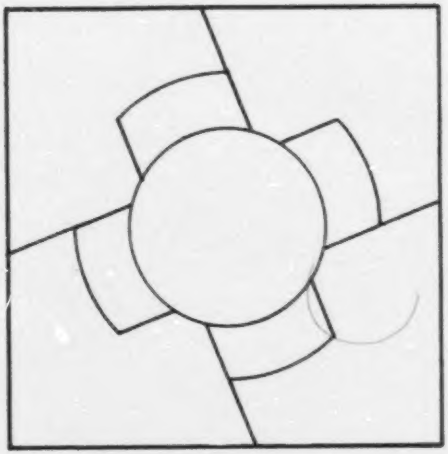

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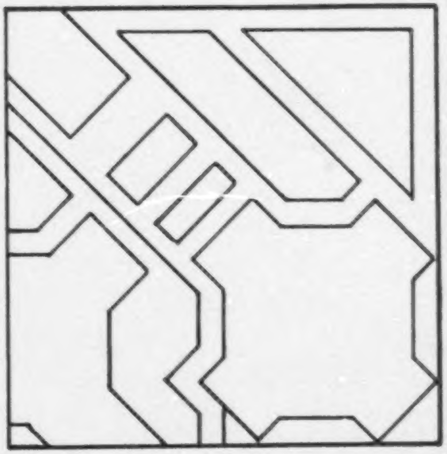

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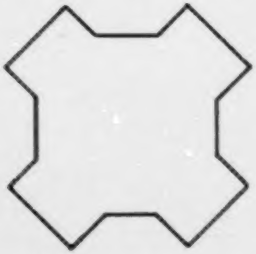

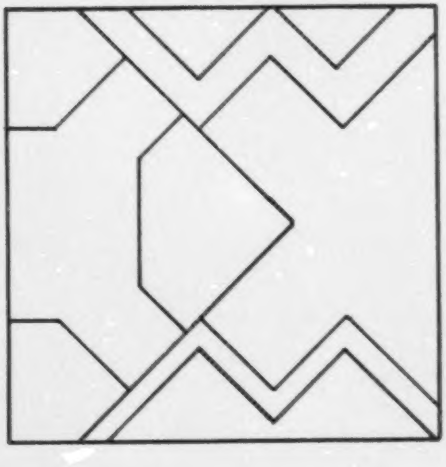

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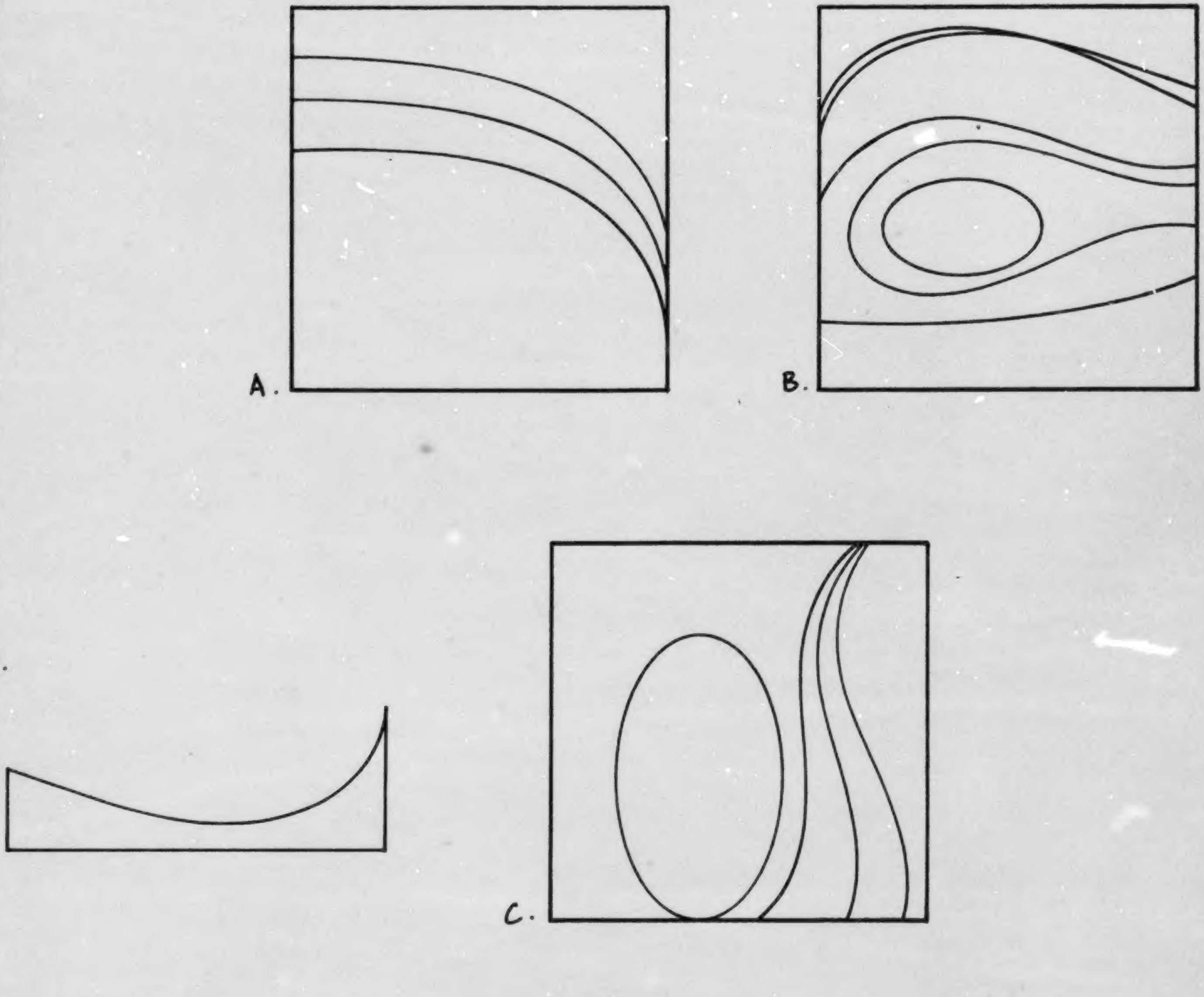
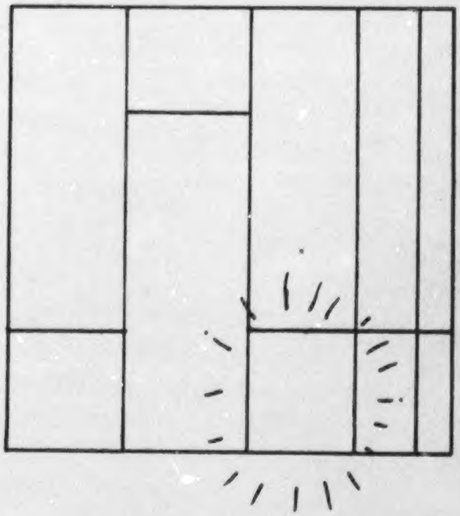
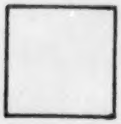
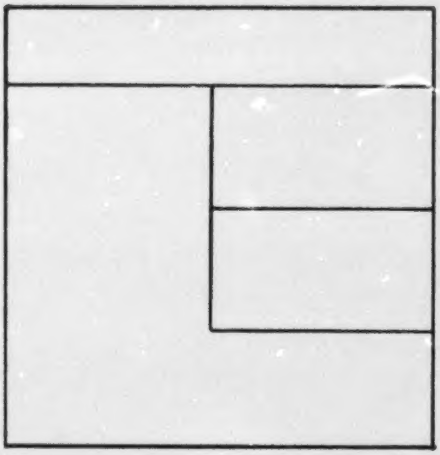


THE NEXT GROUP OF SHAPES WILL BE MORE DIFFICULT TO PICK OUT BECAUSE THEY ARE HIDDEN DEEPER IN THE PATTERNS.







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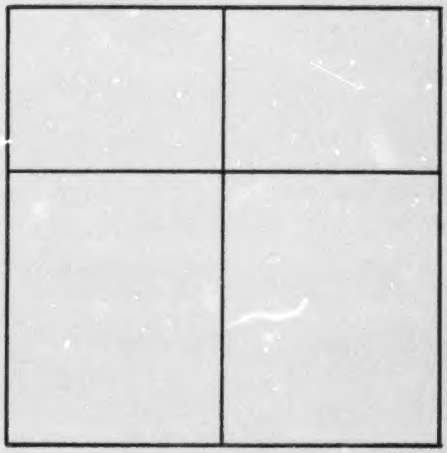

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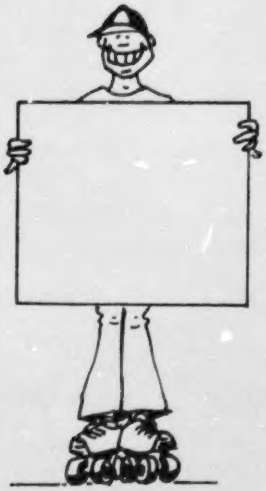

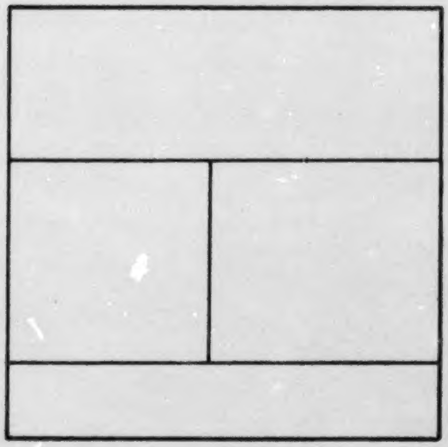

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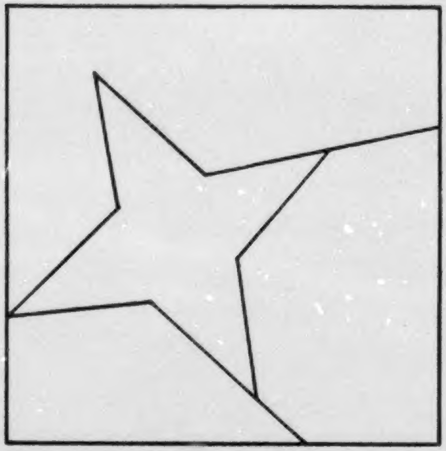

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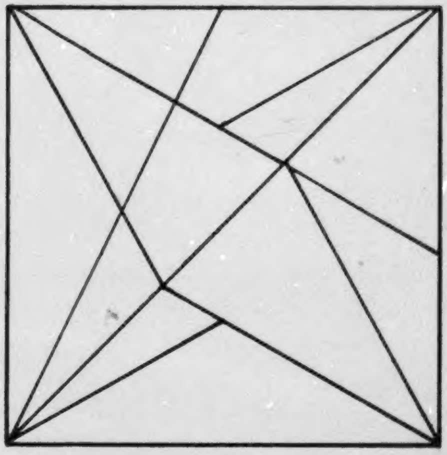

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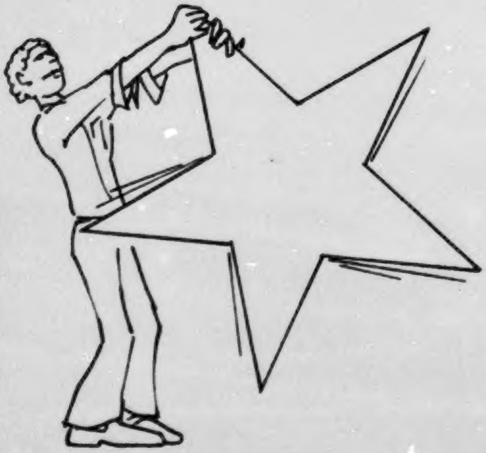

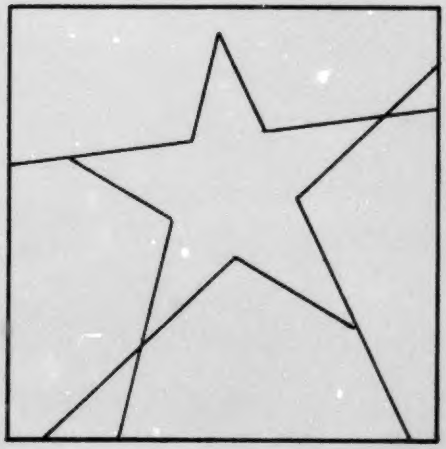

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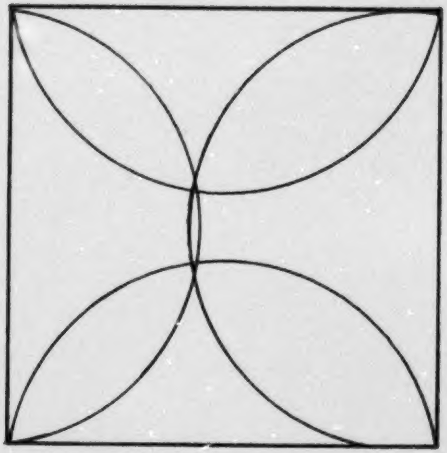

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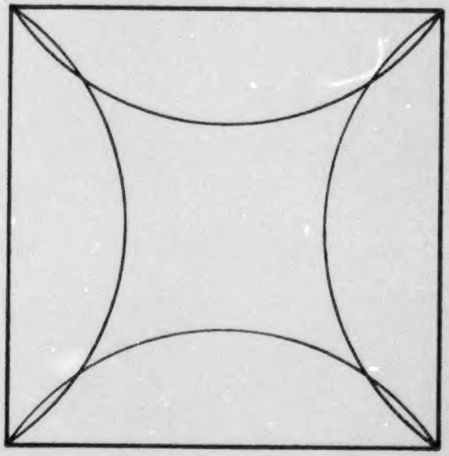

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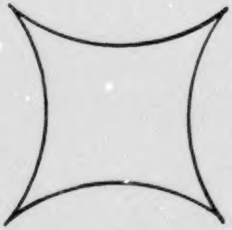

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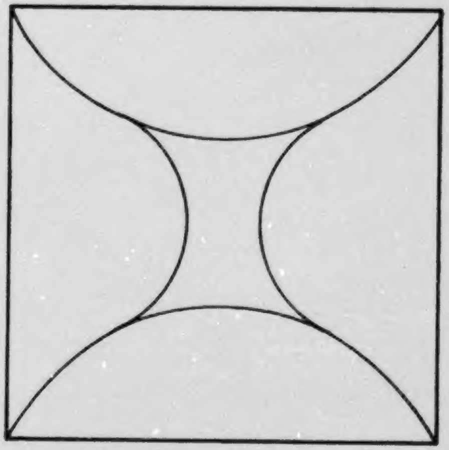

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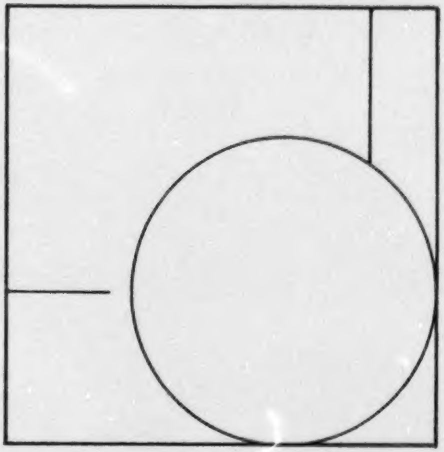

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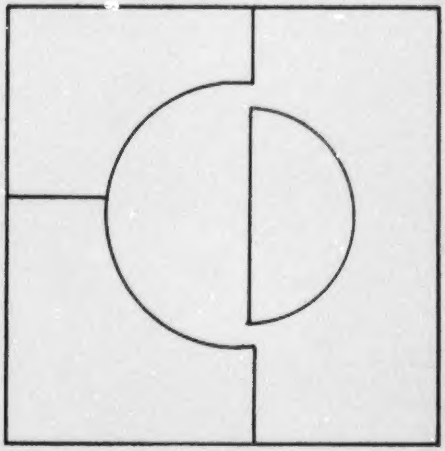

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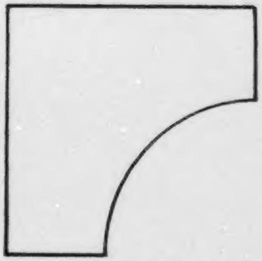

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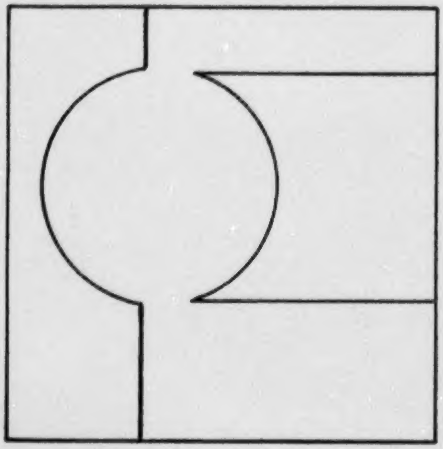

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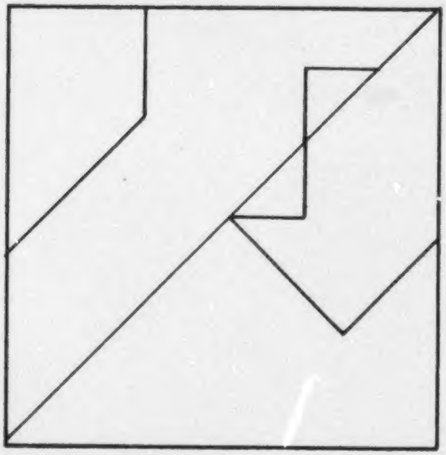

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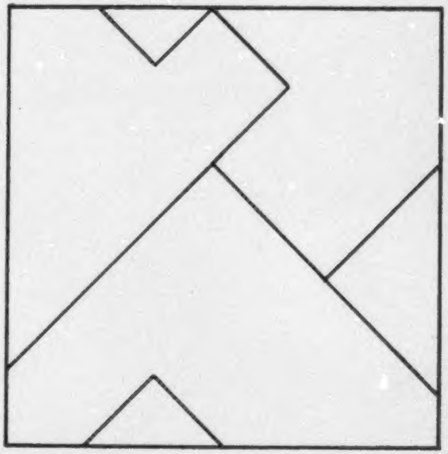

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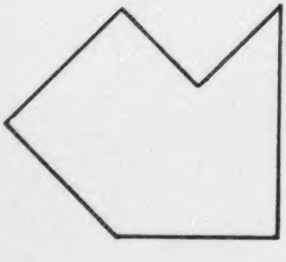

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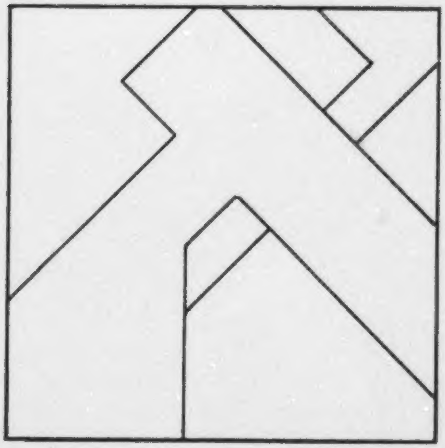

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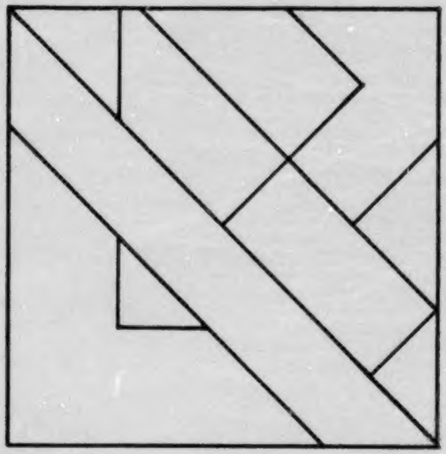
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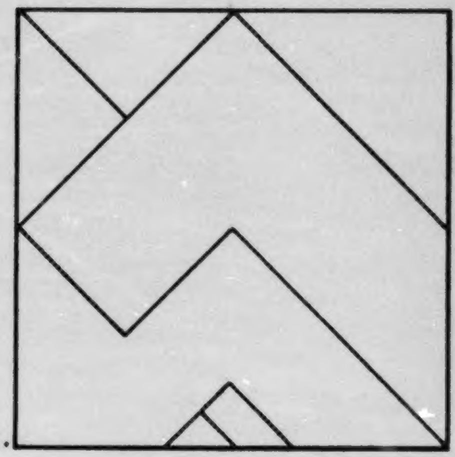
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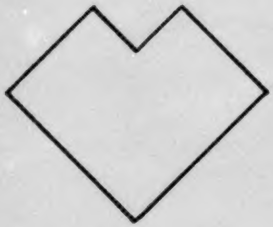

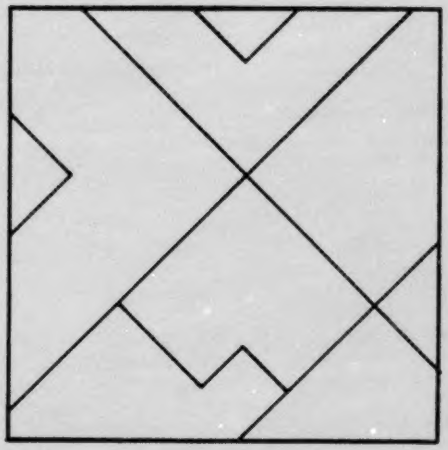
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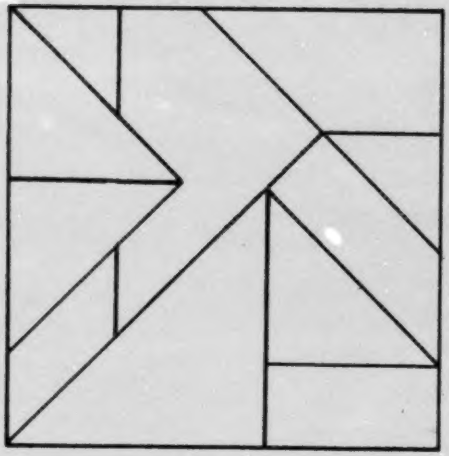

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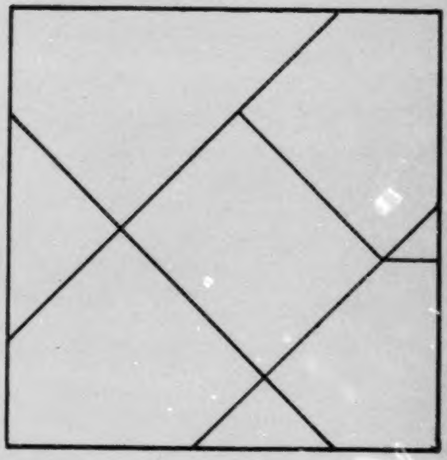

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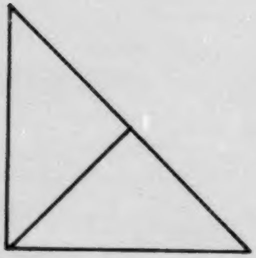

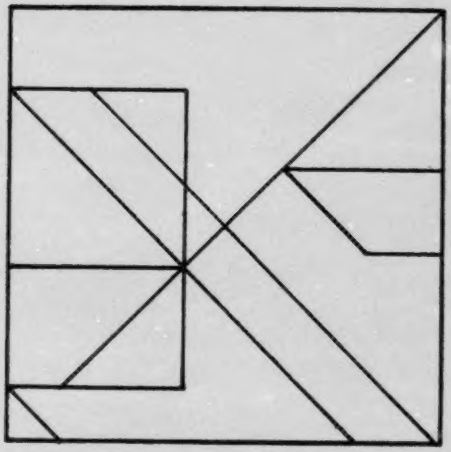

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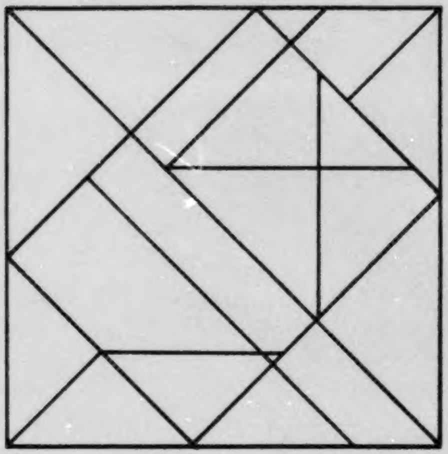
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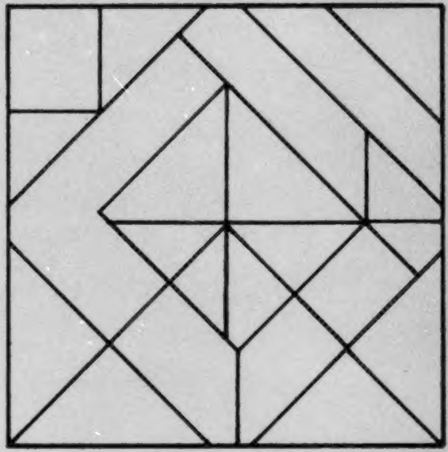
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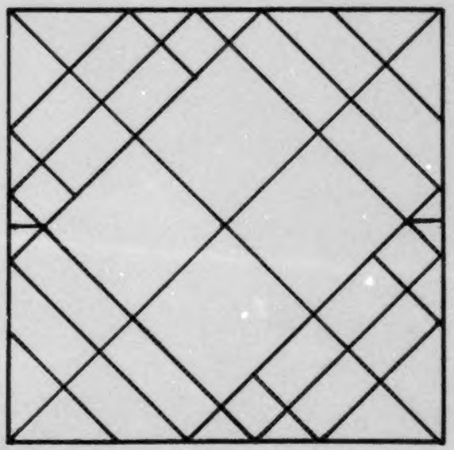
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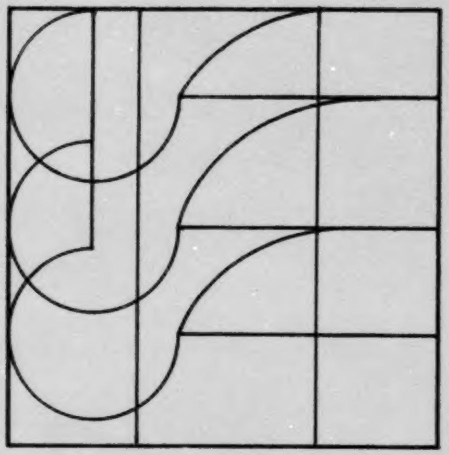

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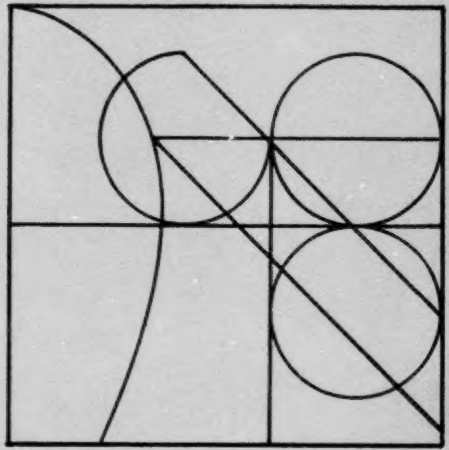
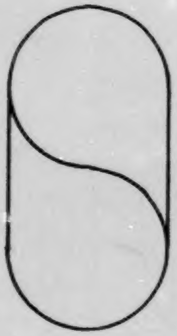
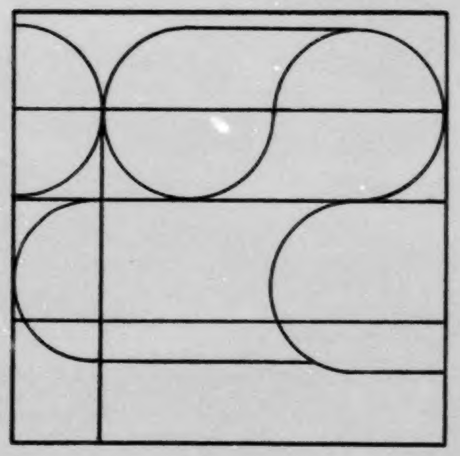


B.

23.





C.

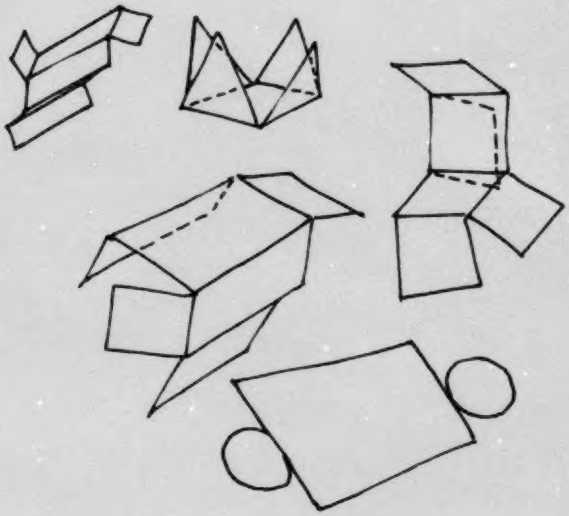
SOLUTIONS
HIDDEN SHAPES

1 A B [✓ C]
2 A B [✓ C]
3 A B [✓ C]
4 A [✓ B] C
5 A [✓ B] C
6 [✓ A] B C
7 [✓ A] B C

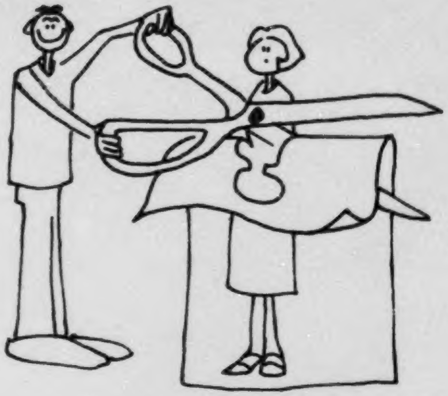
8 A [✓ B] C
9 [✓ A] B C
10 [✓ A] B C
11 A B [✓ C]
12 [✓ A] B C
13 A [✓ B] C
14 A [✓ B] C
15 A B [✓ C]

16 A B [✓ C]
17 A [✓ B] C
18 A [✓ B] C
19 A [✓ B] C
20 A B [✓ C]
21 [✓ A] B C
22 A B [✓ C]
23 A B [✓ C]

Cutout Forms



CUTOUT FORMS



APPLICATION

Many times we are faced with the task of assembling three-dimensional objects from pictures. For example, you might want to assemble an "easy-to-put-together one-hundred-piece" space toy the night before a birthday party. More often than not, unassembled household goods are less expensive. The instructions are given in drawing form and may be ambiguous. The best way to cope with such a problem is to visualize the completed object in three-dimensional space, going from the two-dimensional drawing.

Architects and draftspersons need to be able to look at cross-sections of objects and visualize them from different angles. Carpenters must be able to construct furniture, cabinets, and so on from two-dimensional drawings. Clothes designers have to visualize a new design and create it from flat pieces.

OBJECTIVE

To create a three-dimensional object from a two-dimensional pattern.

DIRECTIONS

Glance through the exercises. The first exercise is an example of the types of activities in this set. Look at the figure in the box on the right-hand side of the page. Then look at the patterns on the left. One of those patterns could be cut out and folded up to look like the figure in the box. Try to do this visually -- imagine the pattern folding up. What would it look like? If it would match the object in the box, circle that answer on the sheet provided. Notice for this set of activities, the answers are drawn for you.

If you get all the exercises correct, you have completed the series of activities on *SPATIAL ENCOUNTERS*.

But, if some of your answers do not match the correct ones, you may want to copy those pages, cut out the patterns and practice folding them up. Do this until you can imagine the patterns folding up without actually doing so.

Additional activities are given under "What Else Can You Do?" on the next page.

CUTOUT FORMS

WHAT ELSE CAN YOU DO?

Make snowflakes by folding a piece of paper and cutting designs out of it.

Assemble models of toys.

Play with Tinkertoys.

Find a book that contains directions for assembling simple wooden toys and construct one.

Draw a bird's-eye view of your house or room.

Find a three-dimensional object such as a book, a hat, or a glass and draw a two-dimensional picture of it. Then cut it out and fold it up. Does it look like the original?

Look at a photograph of an object such as a bridge, a kite, a boat, or an abstract shape. Reproduce it using straws, toothpicks, or match sticks. Clay or glue can be used as connectors.

Use Play-doh or blocks to construct a three-dimensional object.

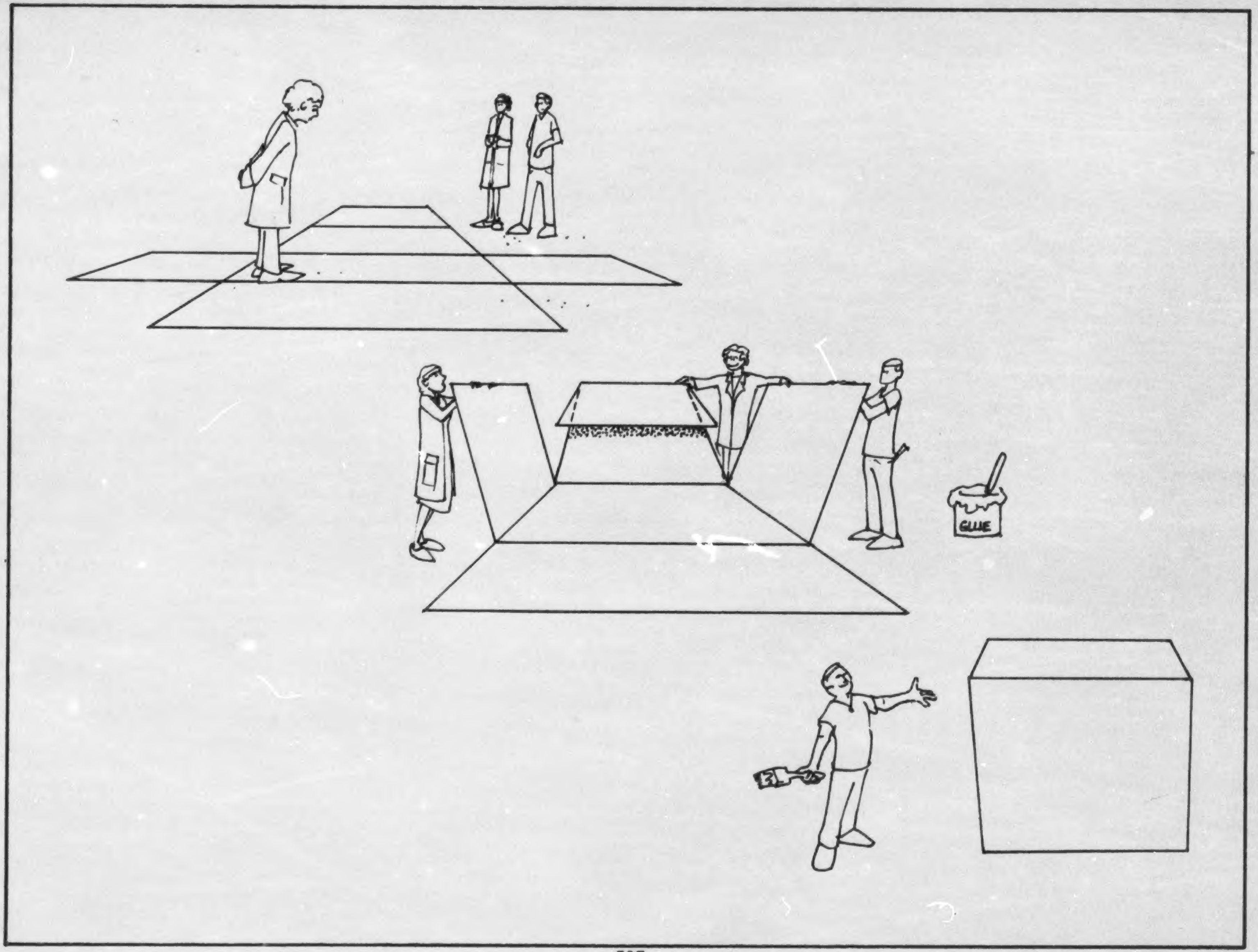
Assemble a simple mechanical system.

Create a collage.

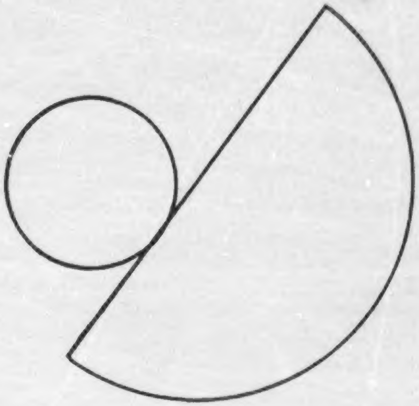
LIST YOUR OWN IDEAS TO IMPROVE YOUR ABILITY TO GO FROM TWO-DIMENSIONAL TO THREE-DIMENSIONAL SPACE

ANSWER SHEET
CUTOUT FORMS

1	A	B	C	7	A	B	C
2	A	B	C	8	A	B	C
3	A	B	C	9	A	B	C
4	A	B	C	10	A	B	C
5	A	B	C	11	A	B	C
6	A	B	C	12	A	B	C


GLUE

A.



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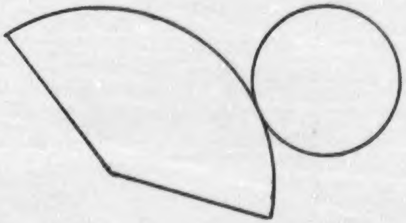

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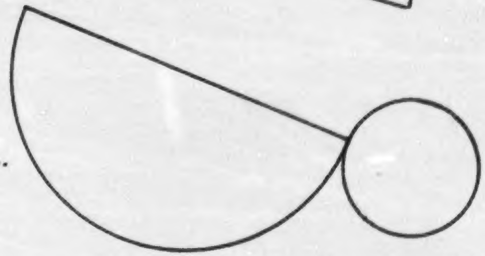
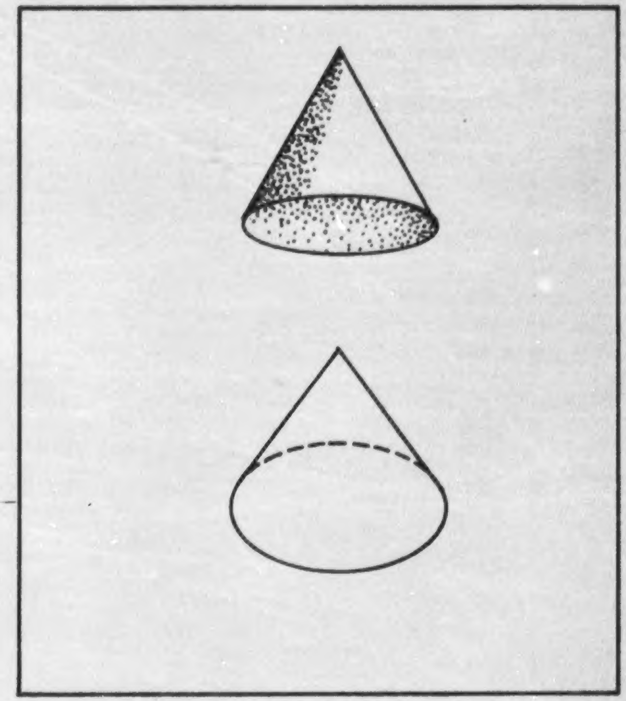
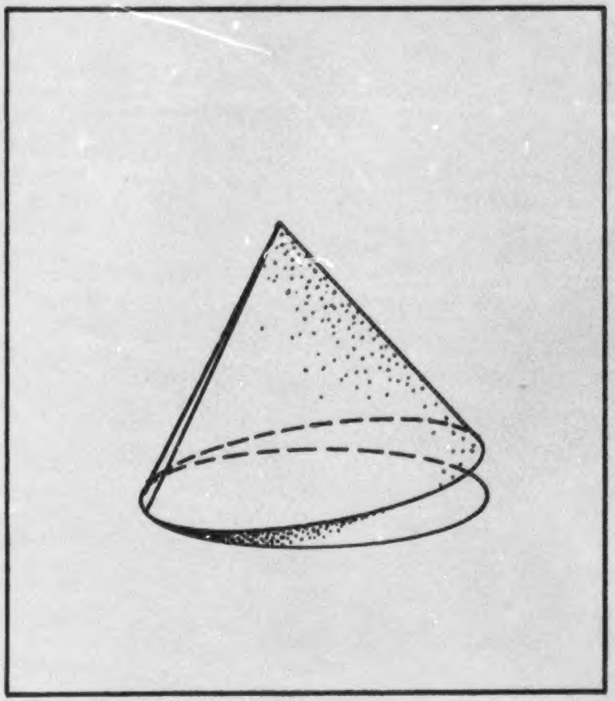




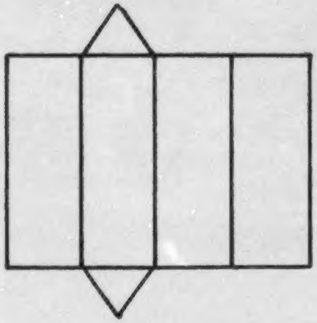
1.

LOOK AT THE FIGURE IN THE BOX ON THE RIGHT. NOW LOOK AT THE PATTERNS ON THE LEFT. ONE OF THE PATTERNS WOULD FOLD UP TO LOOK LIKE THE FIGURE IN THE BOX. WHICH ONE IS IT? CIRCLE THE CORRECT ANSWER. NOW CHECK YOUR ANSWER ON THE NEXT PAGE.



ANSWER B.

A.



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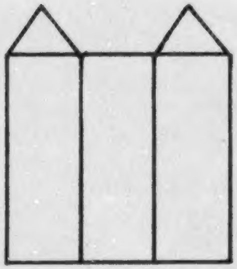

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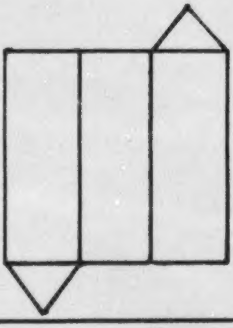

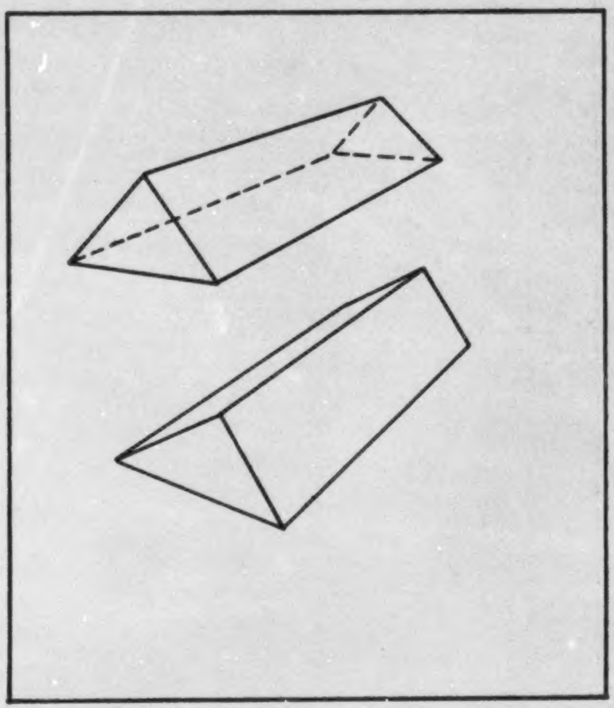

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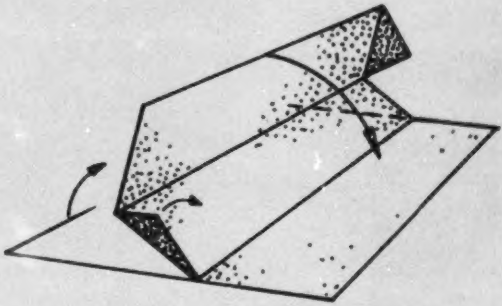
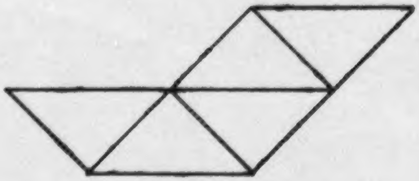


ANSWER C.



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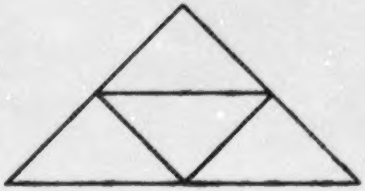

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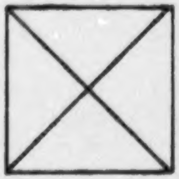

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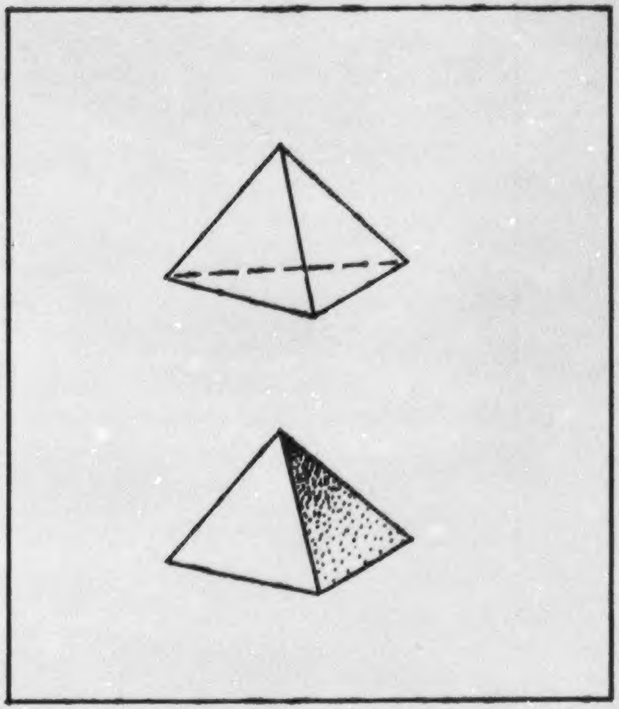

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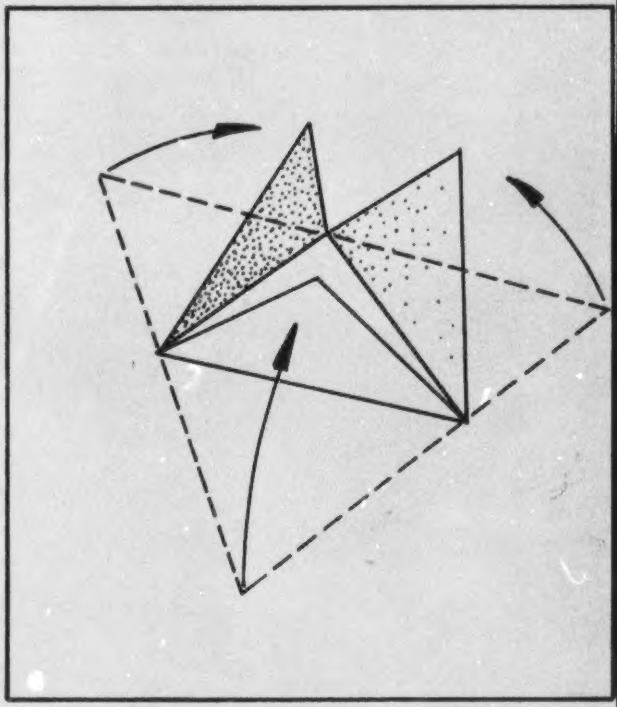

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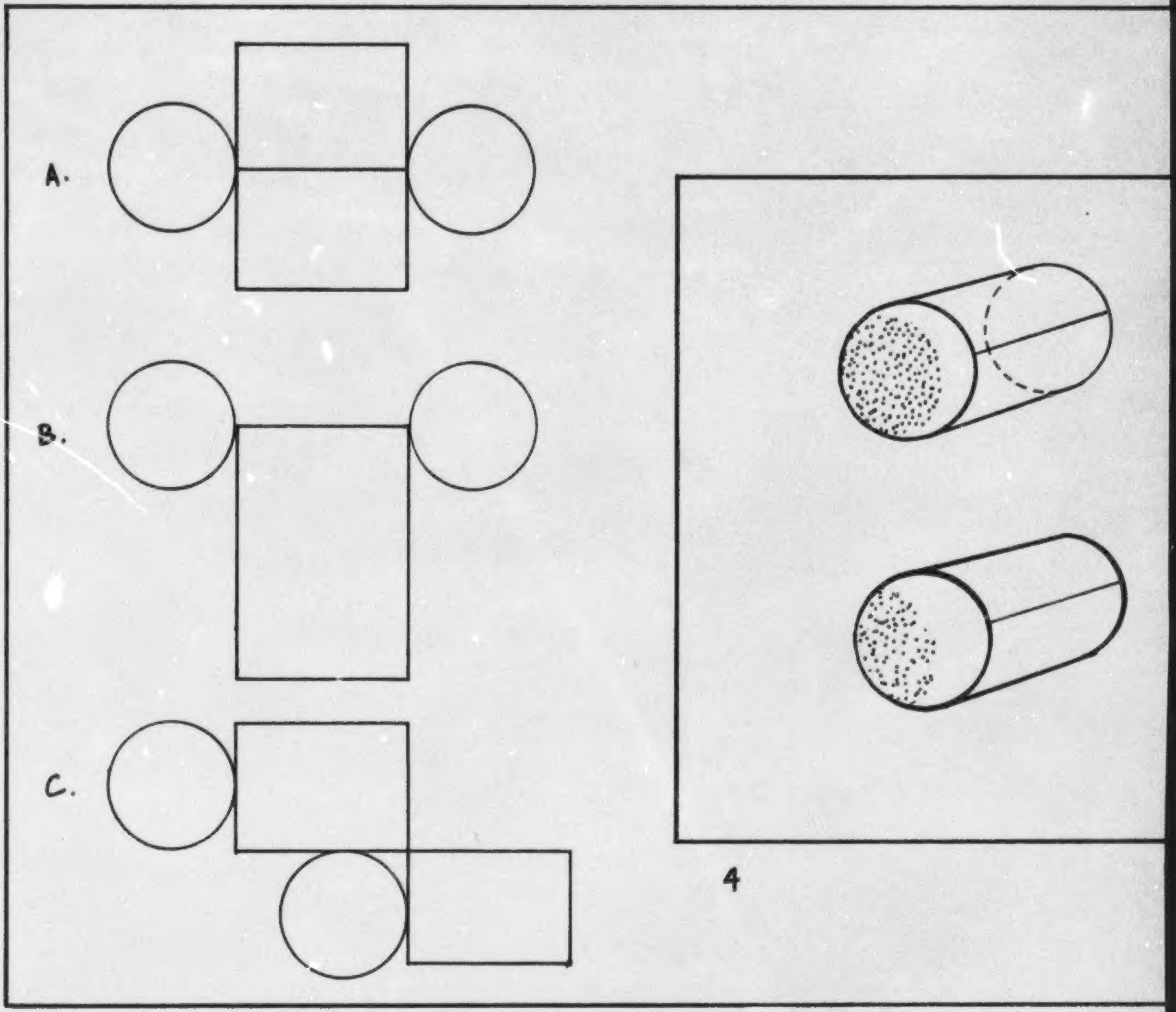
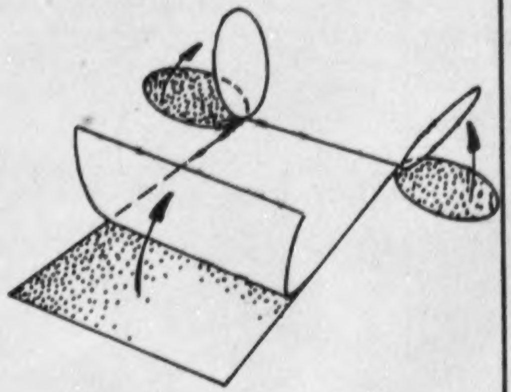

A.
B.
C.
4



ANSWER B.

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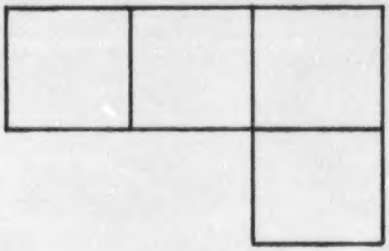

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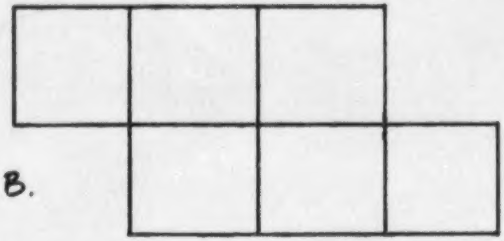

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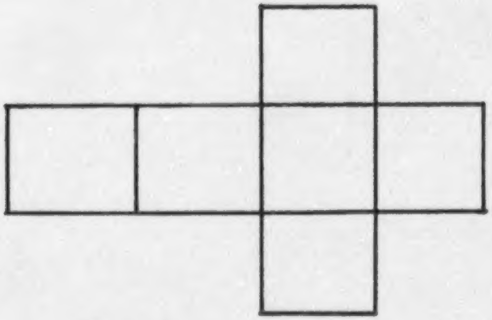

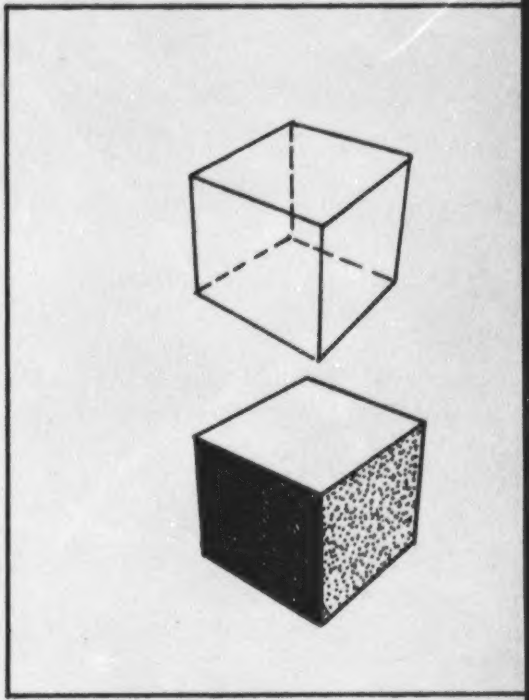

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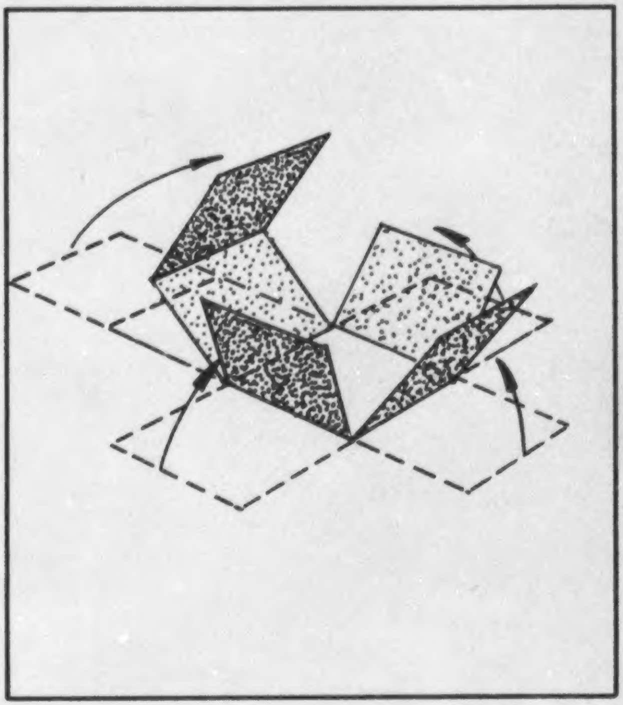

ANSWER C.

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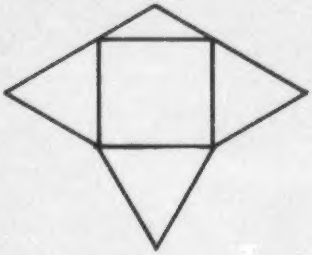

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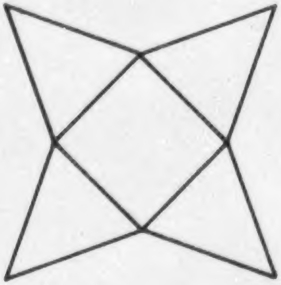

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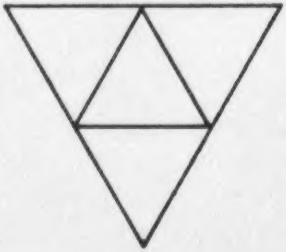

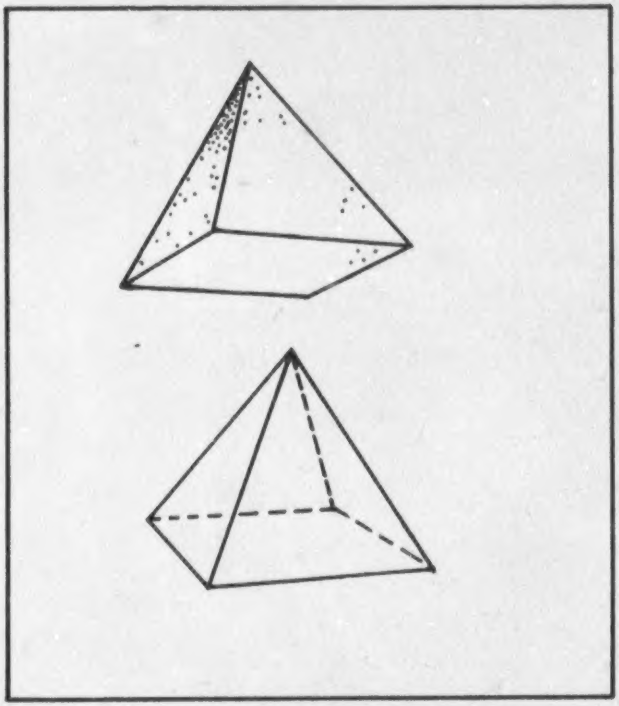

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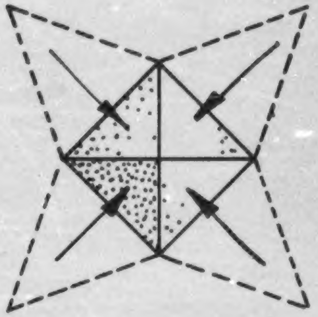

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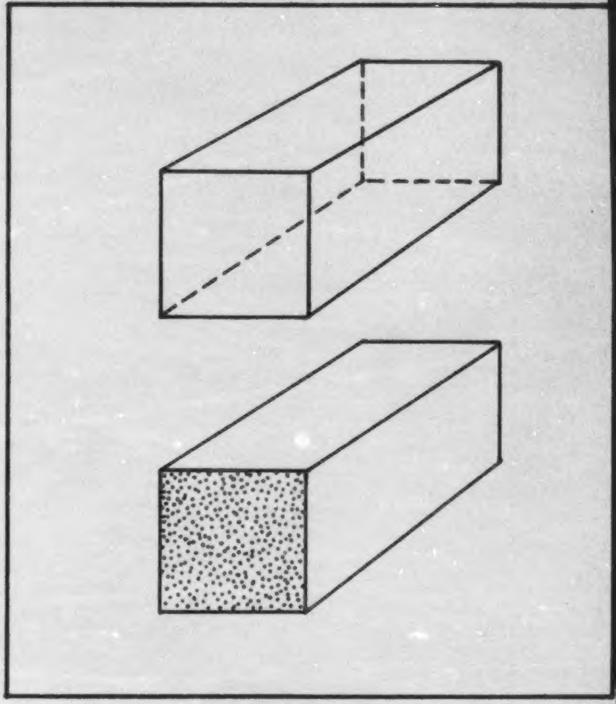

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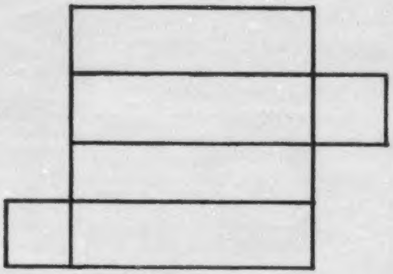

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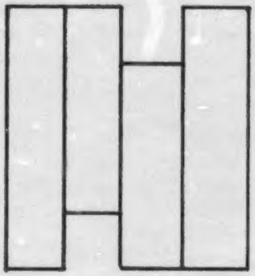

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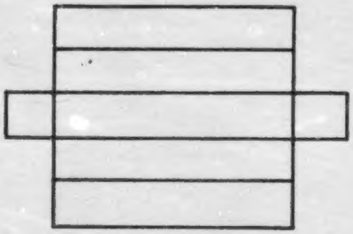
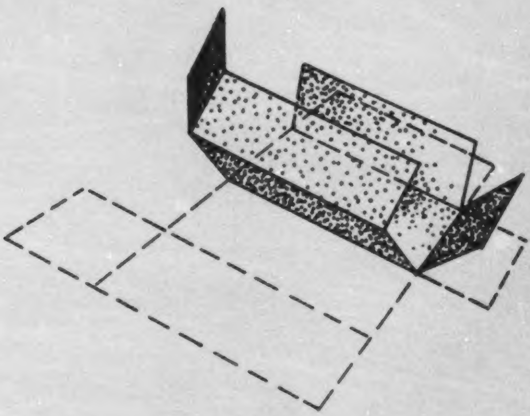
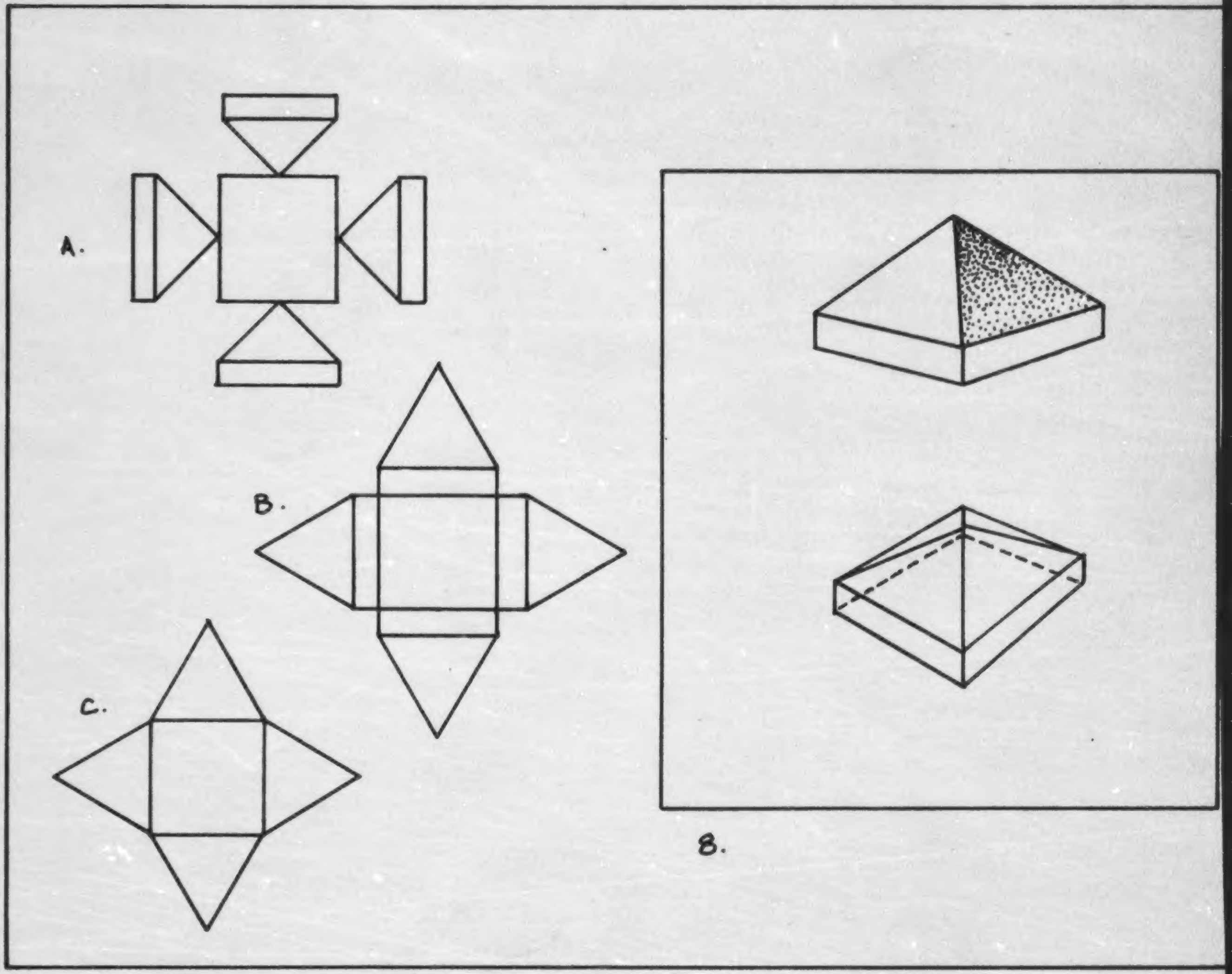
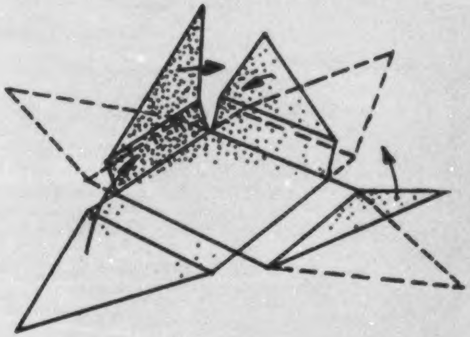




ANSWER A.


A.
B.
C.
8.



ANSWER B.

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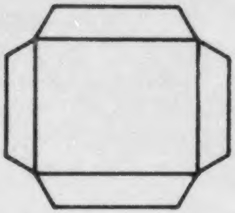

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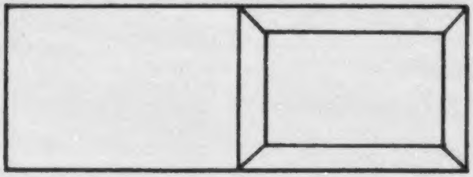

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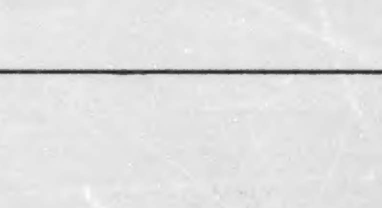

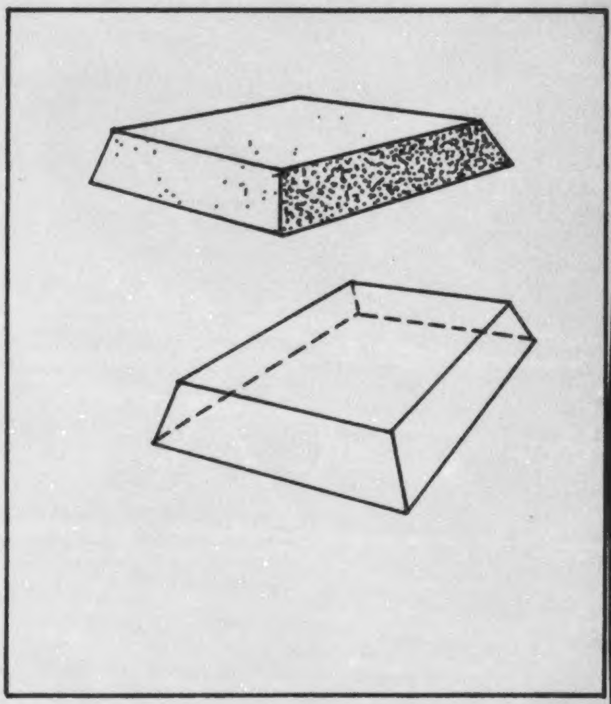

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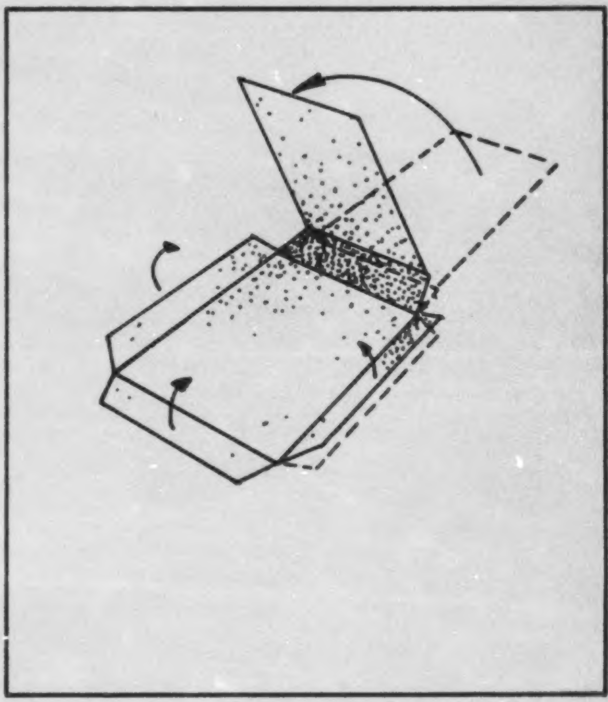
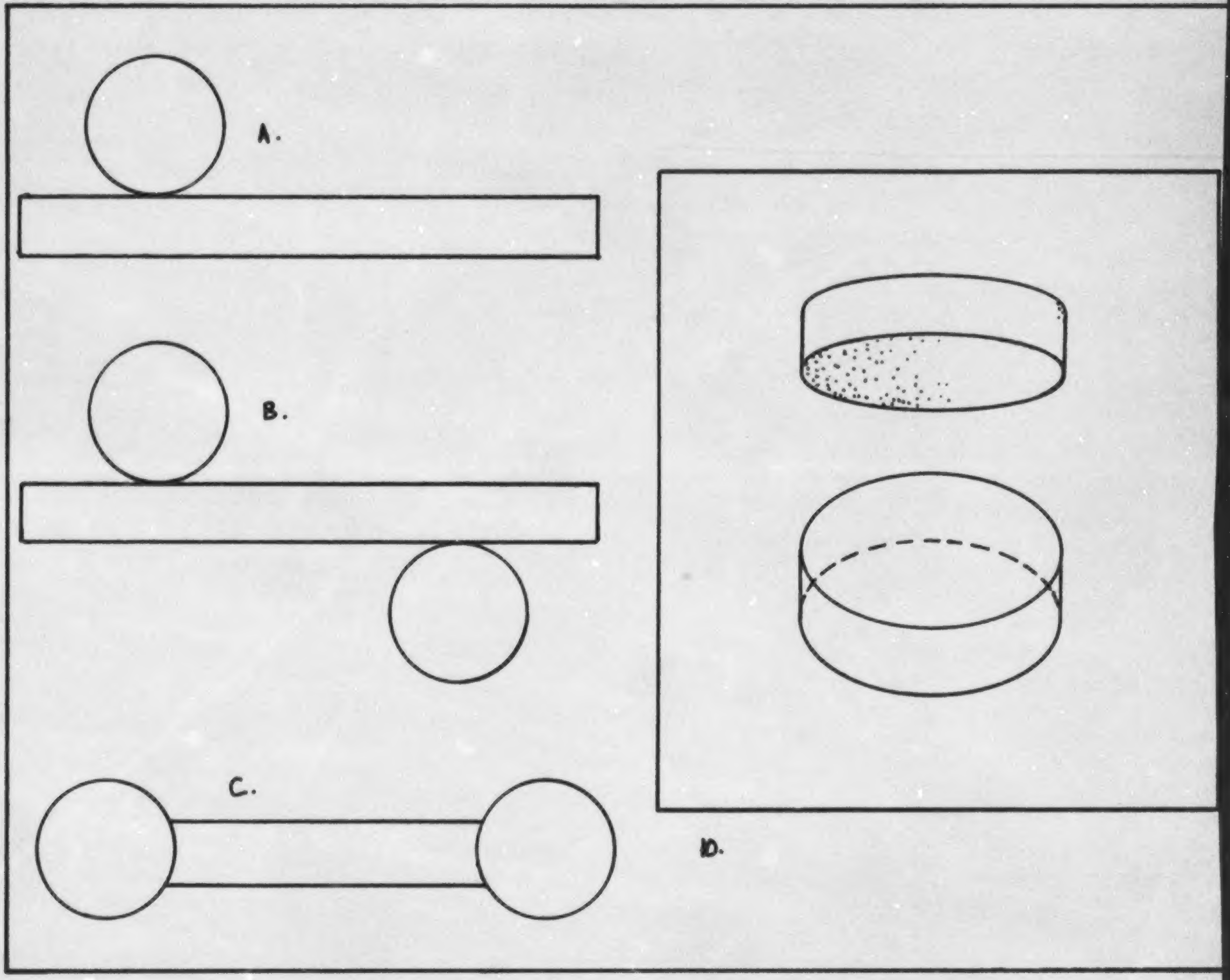


ANSWER C.


A.
B.
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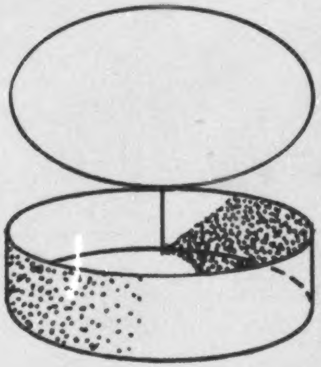
D.



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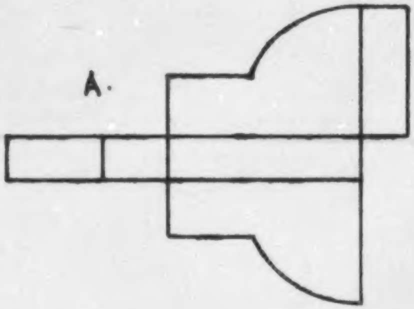

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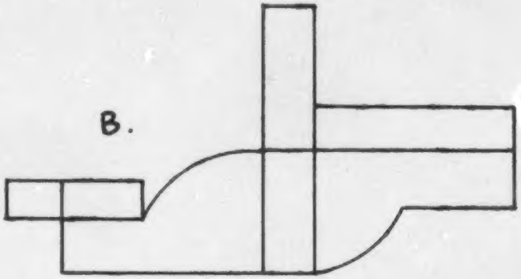

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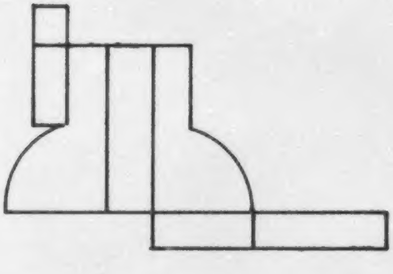

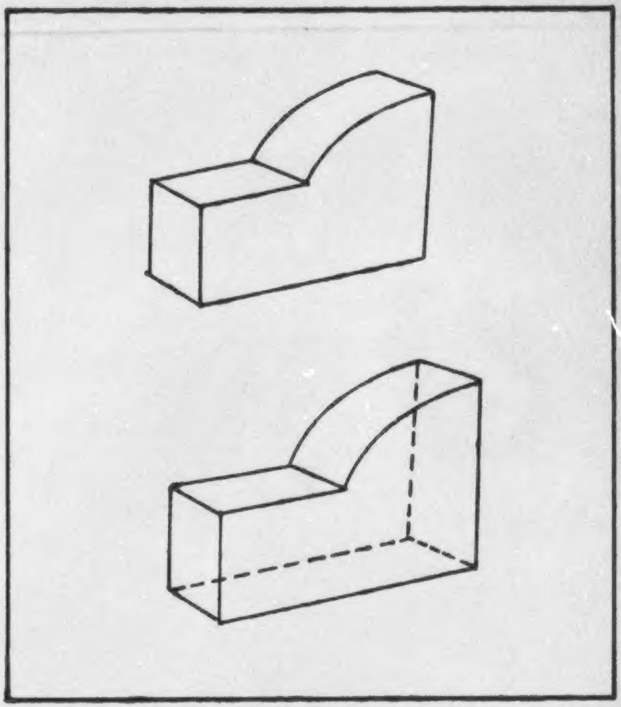

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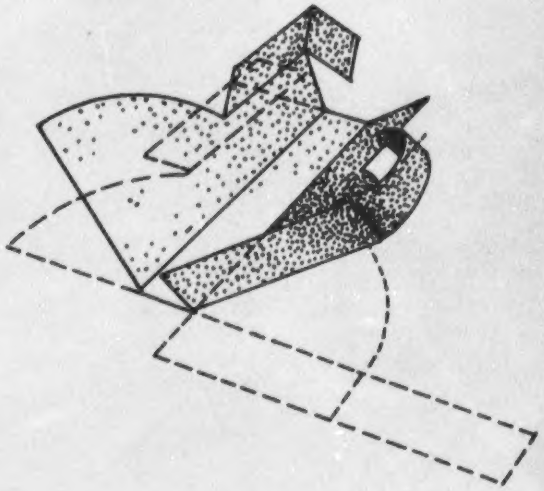

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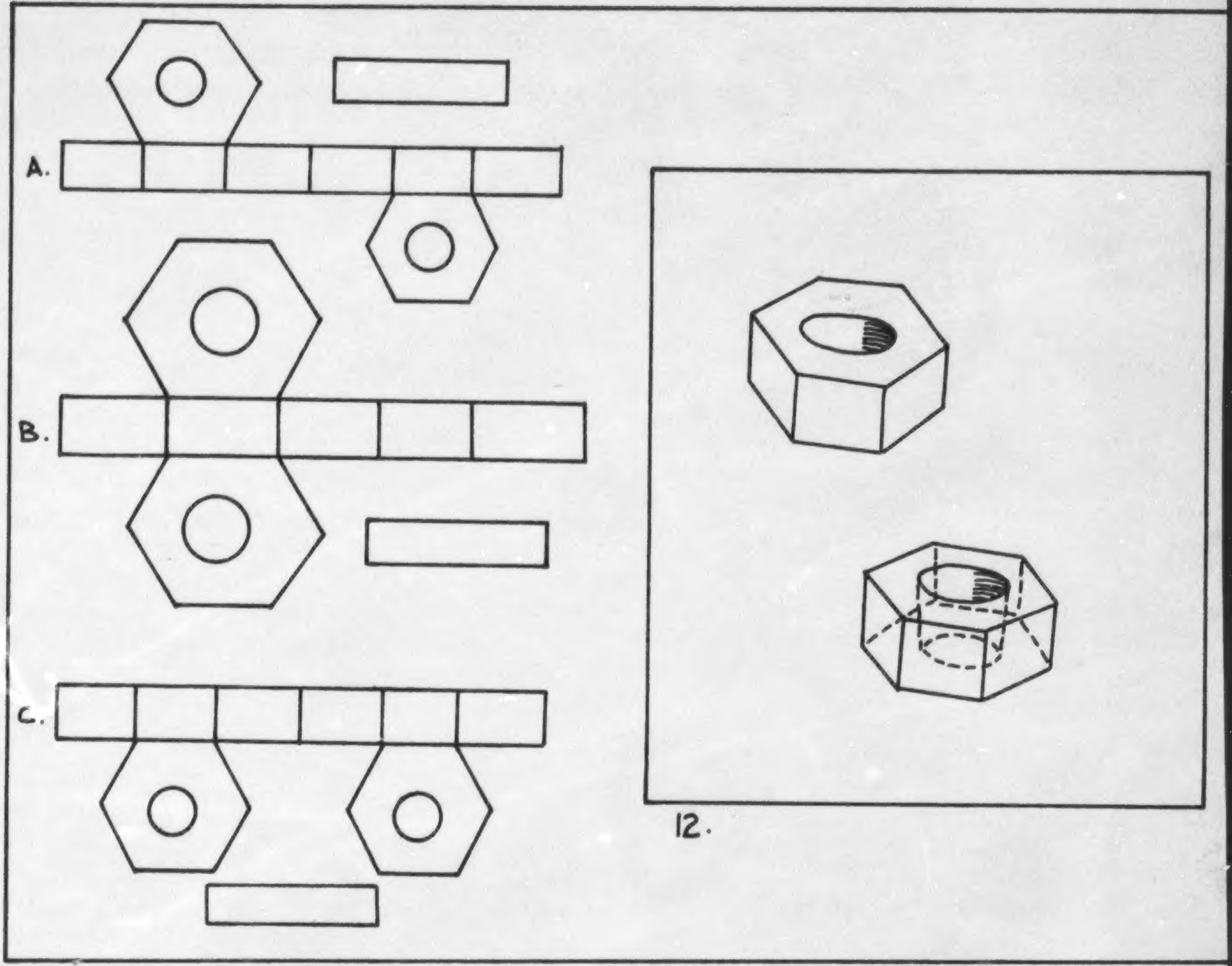
A.
B.
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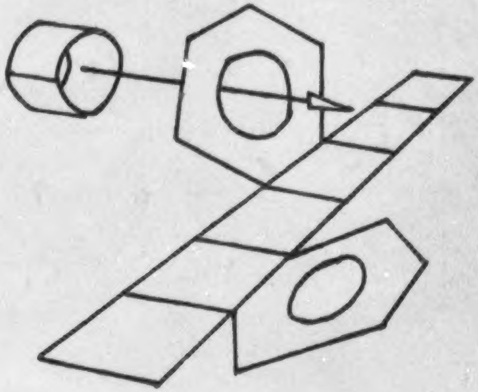

ANSWER A.

SOLUTIONS
CUTOUT FORMS

1 A [✓ B] C

2 A B [✓ C]

3 A [✓ B] C

4 A [✓ B] C

5 A B [✓ C]

6 A [✓ B] C

7 [✓ A] B C

8 A [✓ B] C

9 A B [✓ C]

10 A [✓ B] C

11 A B [✓ C]

12 [✓ A] B C

Careers

The ability to perceive spatial relationships is an important aspect of many careers. Among them are:

Acoustics
Aerodynamics
Airline and Airport Management
Anthropology
Architecture
Art and Design
Astronomy
Astrophysics
Automechanics
Aviation

Bacteriology
Biochemistry
Biology
Botany

Carpentry
Ceramics
Chemistry
City Planning
Communication Arts
Computer Science
Construction
Cryogenics

Dance
Dentistry
Drafting
Driver Training

Earth Science
Engineering, all types
Environmental Planning

Fish and Wildlife Management
Forestry

Geography
Geology
Geophysics
Glass Technology
Graphic Arts and Printing

Health Services
Horticulture
Hydrology

Industrial Arts
Industrial Design
Industrial Hygiene
Industrial Technology

Landscape Architecture

Mathematics
Medical Technology
Medicine
Metallurgy

Nursing

Pharmacy and Pharmacology
Photogrammetry
Physical Education
Physics
Physiology
Plumbing

Quality Control

Radiology
Recreation

Shipping

Telecommunication Arts
Therapy, Occupational and Physical
Traffic and Transportation

X-Ray Technology

Suggested Readings

Block, J. H. "Issues, Problems, and Pitfalls in Assessing Sex Differences: A Critical Review of *The Psychology of Sex Differences*." *Merrill-Palmer Quarterly* *22* (1976): 283-308.

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Downs, R. M., and Stea, D., eds. *Image and Environment: Cognitive Mapping and Spatial Behavior*. Chicago: Aldine Publishing Co., 1973.

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